



CALFED SCIENCE FELLOWS PROGRAM



In cooperation with the
California Sea Grant College Program

FELLOWSHIP APPLICATION COVER PAGE

APPLICANT TYPE

☐ Postdoctoral Researcher ☒ Ph.D. Graduate Student

PROJECT NUMBER

PROJECT TITLE

Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks

FINANCIAL SUMMARY

First Year CALFED Funds Requested: \$49,375.00


Total CALFED Funds Requested: \$98,750.00

Duration: 2 years

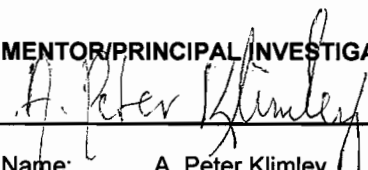
Proposed Start/Completion Dates: 09/01/08 to 08/31/10

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Will animal subjects be used? ☒ Yes ☐ No

APPROVAL DATE: 6/23/2006 PROTOCOL #: 13201 PENDING: Addition of numbers approve

Does this application involve any recombinant DNA technology or resea ☐ Yes ☒ No

Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks

Introduction:

The recent closure of the ocean sport and commercial salmon fisheries off the California coast emphasizes the importance of understanding migration and mortality in Pacific Salmonids. However, researchers have focused relatively little attention on migratory movements and success of juvenile and adult salmonids in the Central Valley, especially steelhead trout. The unique configurations of the Sacramento River Basin and estuaries require Pacific salmonids to travel farther and through larger and more altered habitat than in most other watersheds. The Sacramento River is heavily managed through the use of dams, water diversions, and levees. Salmonids have lost a large proportion of their native habitat, and the remaining habitat has been heavily altered. Thus, studies specific to the Sacramento River are crucial to advance understanding of the species in this particular ecosystem.

Purpose:

I propose to conduct a comparative study of juvenile and adult steelhead trout, originating both from the wild and a hatchery, that will reveal 1) reach-specific success rates; 2) reach-specific movement rates; 3) environmental and anthropogenic impacts; 4) rates of iteroparity; and 5) behavioral differences.

Need for New Knowledge:

Pacific salmonids are both an important economic and cultural resource of the Central Valley. The migratory movements and success of juvenile steelhead trout and chinook salmon in the Central Valley have significant research interest to a variety of groups, such as fishermen, managers, and water boards. Wild steelhead trout and late-fall Chinook salmon runs are supplemented by the addition of juvenile salmonids from a number of hatcheries, including Coleman National Fish Hatchery, American River Hatchery, Feather River Hatchery, and Comanche Hatchery on the Mokelumne River. Collectively state and federal hatcheries in the Central Valley contribute millions of chinook each year to the watershed. Currently, researchers have little information about the migratory movements of either the wild or hatchery species, although there is currently an ongoing research program, funded by CALFED, to gather this data. To improve the management of each stage of steelhead trout and enhance the success of their various stocks (hatchery and wild), researchers need to learn more about the behavior and migratory success of hatchery and wild fish.

The majority of data collected on migratory movements of juvenile salmonids in the Central Valley is drawn primarily from CWT mark recapture studies (Brandes and McLain 2001; Snider and Titus 2000). New technologies make it possible to repeatedly detect a migrating fish along its path. With the advent of miniature acoustic tags, it is now possible to quantify reach specific rates and migratory pathways for individual fish. This data is especially important for classifying corridors or migratory routes of importance and minimum survival rates in the Sacramento River, San Francisco Bay Estuary, and Sacramento/San Joaquin Delta, an area of high concern for fish survival due

to pumping facilities and predation by invasive species. Ultrasonic tags and automated monitors can be used to perform mark-recapture analysis. Researchers can now record the time a specific fish passes a known location without impeding or handling it in any fashion. Thus, researchers have no influence on the fish's migratory behavior. Moreover, the use of ultrasonic tags and monitors eliminates the need to sacrifice captured CWT fish to gain data. Most crucially, the ultrasonic tags and monitors now make it possible for researchers to reconstruct the timing and pathways of successful fish in order to examine correlations with environmental and physiological variables.

Because salmonids have steadily declined in number over recent years, it is crucial to understand what environmental, physical and anthropogenic processes affect all life histories and stages of these populations. Basic telemetry work can greatly improve our understanding of the behavior and physical processes that govern the movements, success, and survival of Central Valley steelhead trout. Through the use of acoustic telemetry it is possible to reconstruct the migratory routes and reach-specific rates of both smolt and adult life stages of Central Valley steelhead trout. This data, coupled with other data such as habitat type, temperature, flow and dissolved oxygen, will help inform management of the species within the effect of riverine conditions. Further, this data can be used in the development of an age structured model to make predictions regarding the contributions of hatchery and wild stocks of steelhead trout to the population.

California Fish Tracking Consortium:

For the past two years the California Fish Tracking Consortium, formed by a CALFED funded project at UC Davis/NOAA, has successfully tagged more than 700 juvenile steelhead trout and many adult steelhead trout. This project has focused primarily on quantitatively assessing the migratory success of hatchery fish with acoustic telemetry. A large array of more than 200 acoustic monitors is currently deployed throughout the Sacramento/San Joaquin Watershed (Figure 1). Monitors have been deployed in the Sacramento River, Yuba River, Feather River, American River, Cosumnes River, Mokelumne River, San Joaquin River, Delta and San Francisco Estuary. Soon there will be an acoustic array stretching from the coast north of San Francisco to the edge of the continental shelf in order to assess early oceanic movement and survival of this species. This vast infrastructure will make it possible to examine adult and juvenile steelhead trout migratory success and behavior with a nominal investment in tags and labor costs.

Mark-recapture:

The tags implanted in the adult steelhead will last for more than three years, making it possible to assess the success of each fish over multiple years. The tags implanted in juvenile steelhead will last for 160+ days, allowing assessment of outmigratory success. Tagging returning wild and hatchery steelhead trout in the Sacramento River Watershed will make it possible to assess the success of the fish in relation to physical and anthropogenic effects. Tagging both wild and hatchery fish will yield important data on differentiation in success between the two classes. Our related findings will have important implications for the overall management of the species, particularly by assessing the effect of straying hatchery fish intermingling with wild

stocks in the watershed. If the hatchery fish produce a lower number of kelts than wild fish, then intermingling of genetics could severely impact the fitness of the species.

Understanding the return rates and the proportion of multiple-year spawners (iteroparous steelhead), or kelts, of wild and hatchery steelhead trout is crucial for the recovery of this iconic species. The goal of this comparative research is to develop a model that predicts how steelhead success rates fluctuate with river and estuarine conditions, as well as what conditions are most conducive to their success.

In addition to the new data collected from the tagged adult steelhead trout, I will also analyze the data from 300 hatchery and 200 wild acoustically tagged individuals (collected by UC Davis and NMFS as part of a CALFED project). This data will be used to obtain estimates of success and movement rates as well as detection probabilities.

It is critical to determine the proper model to use for mark recapture data, which becomes even more significant when examining multiple data sets related with one another (Burnham et al. 1995). The Cormack-Jolly-Seber model is ideal for examining the survival and recapture probabilities of juvenile chinook salmon and steelhead trout in the Sacramento River Watershed. Survival or recapture probabilities can be functions of external factors in the Cormack-Jolly-Seber models. Burnham et al. (1995) give several examples such as North's 1979 article including winter conditions, Sandland and Kirkwood's 1981 piece on capture history, and Colbert and Lebreton (1985) animal body condition as an example of another type of covariate.

While the Cormack-Jolly-Seber model is useful for the emigrating chinook in the river, it lacks some desirable features for the steelhead trout throughout the system and chinook salmon in the Delta. In these cases using a multistrata may be more advantageous since the individuals can choose to migrate down different routes when they reach the Delta and have been known to back and forth between sites in tidally influenced areas. In addition the steelhead trout have been observed moving upstream or leaving the area of a monitor for an extended period of time and returning days later. For this sort of system a multistrata model may be more useful since you can include sightings at site "A" then "B" and back to "A" again. Instead of using "1" and "0" the multistate approach uses "A, B, C..." to describe the capture history of the individual, so an individual could have an encounter history such as the one below White et al. (2006):

BCACC

So the fish was detected at site B then C bypassed or went undetected at B and was subsequently detected at A and then at C the next two sampling periods. This sort of analysis is useful in the Delta.

The data collected on juvenile and adult hatchery and wild steelhead trout from the larger CALFED study will be analyzed with Program MARK in a Cormack-Jolly-Seber model to create success and detection probabilities. In the Delta a multistrata model will be used in Program MARK to better assess route selection and movements affected by flow in terms of success and detection probabilities. From this analysis, problematic areas for the fish and potential areas of high mortality can be identified. The environmental data collected at key sites throughout the watershed can then be parameterized and added to improve the model to examine the potential impact of individual variables or combinations of variables. In turn, better informed mitigation actions for the Sacramento River Watershed can be developed.

Finally, data collected from the juvenile and adult steelhead trout can be used to develop an age-based model to better determine the contributions of hatchery and adult steelhead trout to the general population. Tagging wild and hatchery individuals will also give us the opportunity to examine behavioral differences of both classes for juvenile and adult fish, which will give insight into the possible mechanisms behind differences in success rates.

Collaborations:

The proposed research endeavor will promote and enhance collaboration with many groups throughout the Central Valley. For instance, it will build upon and strengthen relationships I have already established with researchers at U.S. Fish and Wildlife Service, California Department of Fish and Game, NOAA, University of California Santa Cruz, University of California Davis, East Bay Municipal Utilities District, E-CORP, Bay Planning Coalition, Department of Water Resources, and the U. S. Army Corps of Engineers. It is also likely to promote collaboration with other groups in the Central Valley, such as SYRCL and Cramer Sciences. In turn, I believe that this project clearly fits both the scientific goals and collaborative goals outlined by CALFED.

Approach/Plan of Work:

I propose to use the extensive array currently in use by researchers at UC-Davis that was developed for the California Fish Tracking Consortium, a CALFED funded project, to study the migratory behavior of both wild and hatchery steelhead trout. Over the past two years I have spent a great deal of time conducting range tests and assisting with tag retention studies and procedures. Through this process we have determined the optimal detection ranges of acoustic monitors throughout various sections of the Sacramento River, San Joaquin/Sacramento Delta, and San Francisco Bay Estuary. We have also determined the optimal tag size for a given sized salmonid allowing us to select tags with the best tag life and signal strength. I will implant 15 wild adult steelhead trout, 15 adult hatchery steelhead trout, 200 juvenile wild steelhead trout, and 300 juvenile hatchery steelhead trout with acoustic tags in 2008/2009.

Acoustic Array:

The development of miniature tags and automated listening stations makes acoustic technologies more applicable to salmonids. Use of this acoustic technology makes it possible to answer many more questions about the movements and reach-specific rates of fish than has been previously possible with any other previous technology. In addition, Vemco's creation of a line of low cost acoustic tags and automated monitors has made such a study cost-effective. The proposed study fits within the category of a mark-recapture study, but the fish are never touched after the surgical procedure and subsequent release, thereby minimizing the effect of handling on tagged fish.

Prior to the deployment of Vemco automated monitors and release of tagged fish, we conducted range tests in the Sacramento River, Sacramento/San Joaquin Delta, and San Francisco Bay to determine the effective coverage area of monitors under various environmental conditions. The tests revealed significantly reduced detection ranges in shallow water (< 2m) and areas of high flow. They also demonstrated that high level,

low frequency noise was capable of blocking tag transmissions to automated monitors. Since 2006, we have strategically placed more than 200 automated monitors at areas that were as acoustically favorable as possible and biologically important (areas of perceived high mortality and confluence) throughout the Sacramento River Watershed. Estuary receivers were deployed in lines or curtains in order to detect fish passing the entire width of the bay, and river monitors were placed in exits and entrances of sloughs and near confluence areas.

The Sacramento River Watershed presents a unique opportunity because of a large infrastructure of acoustic monitors deployed from Redding, CA to the continental shelf break just north of San Francisco, CA. Overall, more than 200 acoustic monitors are now deployed throughout the study region. In the San Francisco Bay Estuary we have deployed “curtain lines” at several choke points to ensure the detection of tagged fish. These lines have been deployed at Rio Vista, Jersey Point, Chipps Island, Benicia Bridge, Carquinez Bridge, San Rafael Bridge, Raccoon Strait, and the Golden Gate Bridge. Since the water is deep and fast moving at the final detection point before fish reach the Pacific Ocean near the Golden Gate Bridge, the curtain line has been deployed as a double and staggered array to ensure passing fish are detected.

In the Delta the acoustic monitors have greatly improved detection ranges compared to other areas of the watershed. Using single monitors at specific sites, such as branching points from the main-stem Sacramento River, it is possible to detect tagged fish and determine route selection. Several branching points in the Delta that have been identified as areas of interest for the survival of fish. Monitors have been placed at Sutter Slough, Steamboat Slough, Miner Slough, Georgiana Slough, the Delta Cross Channel, Three-mile Slough, and several other areas of confluence and branching. These sites make it possible to determine which route a fish utilizes and if the success rate of fish using a specific route is lower than that of fish using another route.

From the city of Sacramento to Cow Creek, a tributary running into the main-stem Sacramento near Redding, CA, monitors have been deployed in pairs. The monitors are offset at least 100 meters upstream or downstream of one another and typically placed on opposite banks. This is done to ensure that fish are detected as they pass by specific locations. Pairing monitors is also a useful way of having duplicate data. This helps protect against data loss from a monitor malfunction, debris causing the loss of a monitor, or in rare instances the vandalism or theft of a monitor. This array is downloaded quarterly and the data is compiled in a centralized database at the NMFS office in Santa Cruz.

Study Design:

During the fall/winter of 2008, I will tag 15 returning wild adult steelhead trout and 15 hatchery adult steelhead trout returning to Coleman National Fish Hatchery. Wild steelhead trout will be captured through hook and line sampling, long lining, and gill netting to tag the proposed 15 fish. The Biotelemetry Laboratory has been successful in hook and line sampling for steelhead trout and gill netting and tagging green sturgeon. We also work with other groups that have caught and tagged adult wild steelhead trout. The captured fish will be anesthetized and implanted with acoustic tags and monitored briefly following the surgical procedure to ensure their recovery.

We have extensive experience tagging fish while on the river, in the laboratory and at the hatchery. To date, we have tagged more than 1500 salmonids with acoustic tags. We have conducted tag effect studies and have developed specialized surgical tables to minimize stress to fish during the procedure. Vemco V16 tags (tag life of five years) will be implanted into all the fish. The V16 tag is an optimal tag size (<5% of fish body weight) for adult steelhead trout, has an appropriate tag life, and has a greater detection range than the V7, V9, and V13 tags which will increase our detection probability. The hatchery steelhead will come from Coleman National Fish Hatchery. These fish will also be tagged with V16 tags.

Before surgical procedures begin, tags are activated, weighed, and sterilized. The hatchery fish will be starved for 24 hours prior to surgery and anesthetized with MS-222. Once the fish are anesthetized they are moved to the surgical table where a pump pushes a flow of water containing a low concentration of MS-222, keeping the fish fully anesthetized throughout the surgical procedure. A small incision is made near the mid ventral line in front of the pelvic girdle. The ultrasonic tag is then implanted into the peritoneal cavity of the fish. The incision is closed with two square knots and excess material is cut off, leaving a clean, closed incision. The fish is placed in a recovery tank and observed until it makes a full recovery. During the surgical procedure data is collected on the weight, length, and condition of the fish (eyes, fins, and scales). In addition, a photo and genetic sample is taken from each fish. The protocol for wild fish surgery will be the same, with the exception of not being starved 24 hours prior to surgery and CO₂ will be used as an anesthetic rather than MS-222 so there will be no required holding period.

In the first year of my study, I will look at differences in the movement and success rates of hatchery and wild steelhead trout. Adults tagged at Coleman National Fish Hatchery have shown ~35% rate return the following year (unpublished data, Null). By tagging hatchery and wild adults it will be possible to examine the differences in return rates and proportion of iteroparous steelhead in each stock. In the second year I will look at the number of returning tagged wild and hatchery steelhead and the proportion of fish that outmigrate to sea following their second consecutive year of spawning.

The extensive acoustic array in the Sacramento River Watershed makes it possible to examine differential success rates of fish according to their route in the Delta as they migrate upstream and downstream. I am interested in noting the cues fish use to begin their upstream or downstream migrations. Gathering reach-specific rate data will help us to know if fish are holding in specific reaches because of habitat (restored or natural) available to them, or if the adults are migrating at steady rates.

In the winter of 2008/2009, tagging 300 hatchery juvenile steelhead and 200 wild juvenile steelhead trout will provide the opportunity to monitor outmigratory movement and success rates, along with migratory timing and route selection. These fish will be implanted with V7 and V9 tags which have long enough tag lives to detect fish over their entire emigration to sea. We have had some success with the tags. In our first year of study, 2006, we detected steelhead which moved past the Golden Gate in May of 2007 and then returned to the bay in September of 2007.

This portion of the project, under the direction of Dr. A. Peter Klimley of UC Davis and Dr. Bruce MacFarlane UC Santa Cruz will be run by CALFED funds granted

to monitor the migratory success of juvenile salmonids. The data collected from the 2008/2009 project will be crucial for identifying areas of high mortality and migratory behaviors of hatchery and wild juvenile steelhead trout. Further, it will provide important information for assessing the impact of varying river conditions over consecutive years. We will appraise correlations in juvenile success with environmental and anthropogenic variables in different stretches of the river.

Environmental data will be collected throughout the course of the study. Each automated monitor is equipped with a HOBO tidbit which records temperature at 15 minute time increments. I will also use data collected at USGS stations throughout the Sacramento River and Delta to examine the response of steelhead trout to changing flows and temperature. Precipitation data will be factored to examine the effect of this variable on the success of fish in different reaches of the river.

By tagging wild adult, hatchery adult, wild juveniles, and hatchery juveniles over consecutive years we will be able to develop a more thorough picture of Central Valley steelhead trout life histories. This data could then be used to develop an age-based model to make predictions about populations from year to year in response to varying conditions. This model would be particularly useful for management and mitigation strategies.

Output/Anticipated Products and/or Benefits:

This project addresses several of the CALFED priorities and missions. It will be a collaborative effort between multiple agencies (UC Davis, NOAA, USACE, EBMUD, USFWS, and Cramer Sciences) involving highly qualified scientists with backgrounds in fisheries, statistics, modeling, telemetry, and management. The project will be conducted in collaboration with the CFTC which is comprised of eight agencies. Researchers such as Robert Null, Pat Brandes, Bruce MacFarlane, Peter Klimley, Steven Lindley, and Joe Merz are members of this group. All of these individuals have specialized skills in research areas pertinent to the study.

This research project has the potential to advance the understanding of environmental and anthropogenic factors affecting the success of the different classes of the fishery. The project will yield important data which will have broad use applications. The project will also provide training for numerous scientists and aspiring scientists in telemetric, mark-recapture, calibration, validation, and database management techniques. In addition to the collaborative nature of the project and utility of the data, the research is also a good fit to the priority areas defined by CALFED. The data collected will be useful for addressing trends and patterns of a population in response to changing environmental and anthropogenic effects. The project will also consider the impact of water flow and water quality on the success and behavior of various stocks and life stages of steelhead trout. Finally, it will elucidate direct performance measurements of wild and hatchery populations of steelhead trout in response to environmental factors.

If granted the CALFED fellowship, I would be able to focus on the proposed research project during my final two years of my doctoral studies. The fellowship and the proposed research would also greatly benefit my research and academic career by putting me in direct working relationships with other scientists, fisheries management specialists and providing data for research papers.

Tagging adult steelhead trout in addition to juvenile steelhead trout would open new areas of population assessment to the larger CALFED-funded study. It also has the potential to intersect with other important research. For example, Steven Teo, a post-doctoral researcher at UC Davis, is currently placing archival tags on adult steelhead which are able to geo-locate adults in the ocean. This is exciting research, since there is a dearth of information about the movements of adult steelhead trout in the ocean. Current data on this topic is derived from archival tags and sea surface temperatures. Dr. Teo is hoping that his results will be sufficiently successful to encourage adding the geo-location tags to acoustically-tagged fish. This means there is the potential to assess not only movements of adult steelhead trout within the watershed, but also in the ocean. This data would deepen and extend models of success and movements of adult and juvenile steelhead trout. It would also add a great deal of significant information to the models assessing the contribution of hatchery juveniles and adults along with wild juvenile and adult steelhead.

The project would benefit the UC Davis Biotelemetry Laboratory by supplying a month of salary for a member of the lab each year of the project. It would help to grow the current number of projects and publications produced by the laboratory, and add to an important body of scientific knowledge. This project would also benefit the P.I., Dr. A. Peter Klimley, with the addition of important data concerning the adult life stage of steelhead trout. This data would complement the laboratory's current work on wild and hatchery juvenile steelhead trout. There has also been money written into the budget to help support the laboratory's boat and travel expenses.

Tagging data on adult steelhead trout will help in the assessment and preservation of Central Valley steelhead. The data collected from the adult steelhead trout may also yield information on the success of adult fish in relation to dredging activities and sites in the San Francisco Bay Estuary. This information would be useful to the Biotelemetry Laboratory which is collaborating with USACE in assessing the impact of dredging activities on salmonids.

The community mentor, Joe Merz Ph.D. of Cramer Sciences, has a positive history with the California Fish Tracking Consortium, and will assist on the project. He also has experience capturing and tagging wild steelhead trout. This project will help expand his experience with telemetry work. It will also lead to co-authored publications and presentations. Dr. Merz has worked with salmonids for many years and this project is of great interest to him, adding to the collaboration he would have with the CFTC.

After the first year of study the data from the adult steelhead trout will be analyzed and presented at the CALFED conference. This data will yield results concerning differences in adult wild and hatchery steelhead trout survival and behaviors, including timing reach specific rates, response to environmental cues, and route selection data. It will also tell us about adult escapement rates and the proportion of iteroparous hatchery and wild fish. All of this data will be compared with the river, estuary, and oceanic conditions at the time of residence to examine possible environmental effects.

Upon completion of the second year of research, both years will be analyzed and presented at the CALFED conference and American Fisheries Society meeting. The data will also be worked up and used in a publication comparing the behaviors and success of adult wild and hatchery steelhead trout. This data will be coupled with the data on the

success and behavior of juvenile wild and hatchery steelhead trout in order to develop a stage-based model for publication in scientific literature.

As noted earlier, there is a severe lack of knowledge concerning Sacramento River steelhead trout. The fishery is heavily supported by hatchery stockings. It is crucial that we assess the contribution of both wild and hatchery fish to the population in order to have quality management and mitigation practices which will facilitate the subsistence of this important species.

With the support of this grant, our ability to collect data on a wider range of individual fish will be greatly enhanced. Given a larger pool of data, we will be able to create an age structure model which will allow the development of estimates regarding the contribution of hatchery and wild individuals. We will be able to estimate the success rate of juvenile wild and hatchery steelhead trout as they migrate to the Golden Gate under varying environmental conditions. I would expect the hatchery fish to have a different survival rate than the wild fish.

Another data set gained by tagging wild and hatchery adult steelhead trout would allow us to examine the rate of successful outmigration. The data collected would also be compared with the environmental conditions encountered by the fish along their migratory route. In the subsequent years following the initial tagging it will be possible to examine differences in return rates of adults and the proportion of fish that spawn and successfully emigrate and return the following year. This information is key for assessing the contribution of hatchery and wild fish. If there is a higher proportion of wild fish reaching the ocean and returning from sea, then these stocks could be considered to be more important to the fishery. In addition, if wild adults have a higher rate of return and spawn multiple years more frequently than hatchery fish, they could be crucial for sustaining the population of steelhead trout in the Sacramento River. If we find that wild fish have higher success rates and proportions of repeat spawners than hatchery fish, then mixing of genetics could also pose problems for wild fisheries if the hatchery adults stray.

Along with assessing the performance and patterns of wild and hatchery stocks, acoustic telemetry also offers the opportunity to examine behavioral mechanisms that could explain differences between the fish. Examining timing and cues that might trigger outmigration of hatchery juvenile steelhead trout versus wild juvenile steelhead trout will suggest significant avenues for additional research. With acoustic telemetry and hatchery fish I have observed a near synchronous response of hatchery juvenile steelhead trout to increases in water flow in the upper Sacramento River following precipitation. Less than 35% of the juvenile hatchery fish responded to the precipitation/increase in flow. However, those fish that did respond to this environmental cue comprised 90% of all fish detected at the Golden Gate Bridge during the study. If we are able to conduct the proposed research, we can significantly extend the validity of this finding.

USFWS in Red Bluff has noted that they have an increase in the number of wild steelhead that they capture following precipitation events during the migratory season (pers. comm.. Bill Poytress). Currently we cannot assess the percentage of wild fish responding to this hypothesized cue, but if there is a difference it would suggest a behavioral difference between hatchery and wild fish that could substantially affect success rates. There may be other behavioral differences among wild and hatchery fish, but to date researchers have only tagged hatchery juvenile and adult steelhead trout. By

tagging wild juvenile and adult steelhead trout, it will be possible to gather data concerning environmental cues, behavioral differences, success rates, movement rates, potential areas of high mortality, habitat preferences, and overall contributions of wild and hatchery stocks.

If we are able to collaborate with another project in addition to our current collaboration with the California Fish Tracking Consortium, it may be possible to examine the affect of ocean conditions on adult steelhead trout and determine a general distribution of Sacramento River steelhead trout in the Pacific Ocean. Steve Teo is hoping to deploy archival light sensing tags to determine oceanic positions within ~60km. Data on the distribution of steelhead trout in the ocean is almost non-existent. Some researchers have used small temperature archival tags to try to answer questions, but the data gained leaves a large possible distribution range for the species. The current knowledge of ~35% return rate of hatchery adult steelhead trout suggests that some data can be gleaned from this methodology. This information would be extremely useful for the project in that we would already know success rates of wild and hatchery fish for both juveniles and adults in response to environmental variables within the river and estuary. The estimated survival rates and knowledge of the oceanic conditions in the defined area would assist in assessing the role environmental conditions and habitat play in determining the success of fish.

Additional Collaborative Opportunities:

In addition there is the possibility of collaborating with Steve Teo, post doc at UC Davis, and tagging hatchery fish with light/temperature sensing archival tags that will make it possible to determine where adults are moving when they are in the ocean.

Summary

There is a severe lack of knowledge concerning Sacramento River steelhead trout. The fishery is heavily supported by hatchery stockings. It is crucial that we determine the differences in behavior and success of wild and hatchery fish populations in order to have quality management and mitigation practices which will facilitate the subsistence and recovery of this species. This project would encourage collaboration among many individuals and groups. It would assist in completing the picture for both wild and hatchery stocks of steelhead trout in the Sacramento River and help to develop an assessment of behavioral differences and the contribution of each stock under year to year environmental differences.

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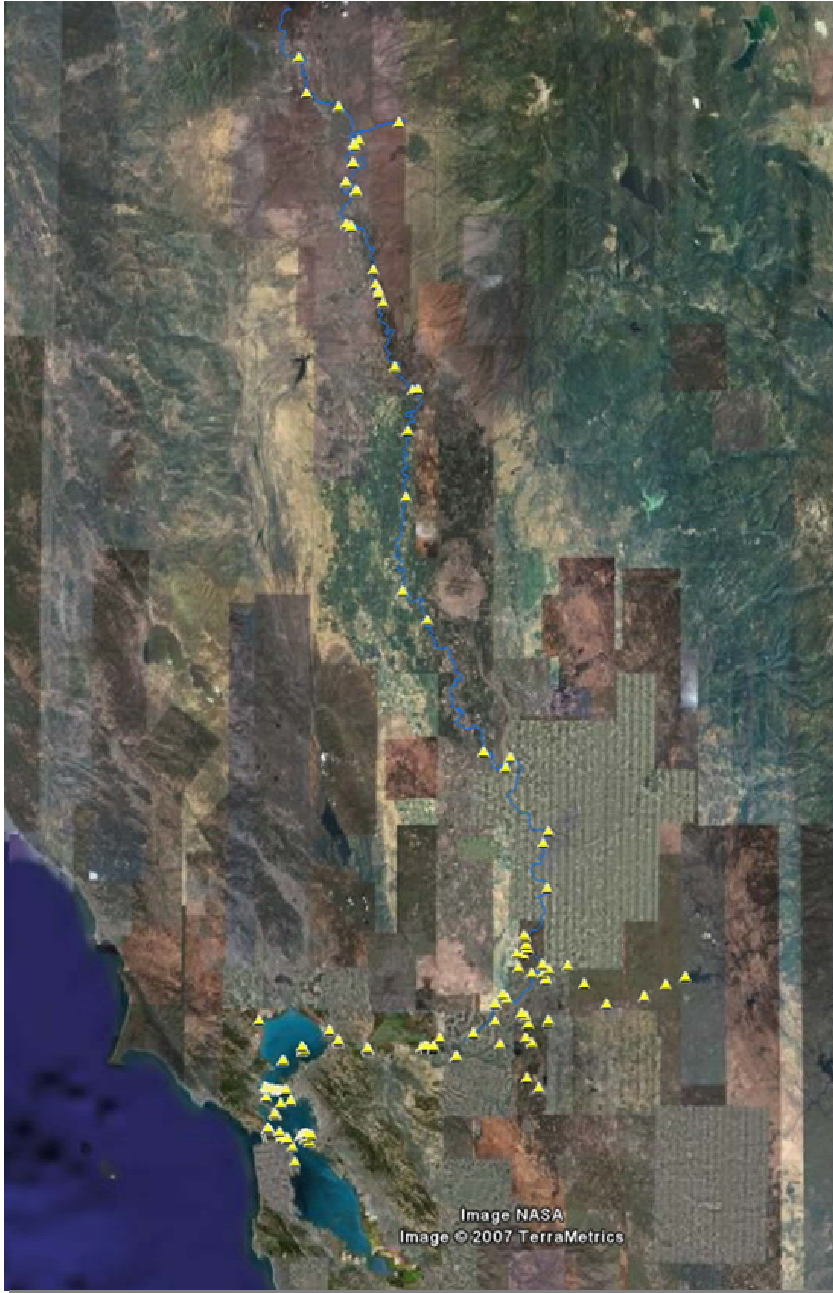


Figure 1: The above map shows the locations of acoustic monitors (yellow triangles) deployed throughout the Sacramento River Watershed as of 2007.

FISCAL YEAR Start Date: 9/1/2008 (mm/dd/yy) End Date: 8/31/2008

| | |
|---------------------------------------|-------------------------|
| <u>PROJECT NUMBER</u> | <u>A. Peter Klimley</u> |
| <u>University of California Davis</u> | <u>NAME OF MENTOR</u> |
| <u>INSTITUTION</u> | <u>Philip Sandstrom</u> |
| | <u>NAME OF FELLOW</u> |
| | <u>CALFED FUNDS</u> |

A. EXPENDABLE SUPPLIES AND EQUIPMENT

| | |
|---|--------------|
| 1. 30 Vemco V16 coded tags @ \$315.00/tag | <u>9,450</u> |
| 2. Surgical Supplies | <u>250</u> |
| 3. Boat fuel and maintenance | <u>800</u> |
| 4. | <u></u> |
| 5. | <u></u> |

TOTAL SUPPLIES 10,500

B. PERMANENT EQUIPMENT

| | |
|----|---------|
| 1. | <u></u> |
| 2. | <u></u> |
| 3. | <u></u> |
| 4. | <u></u> |
| 5. | <u></u> |

TOTAL EQUIPMENT

C. TRAVEL

| | |
|--|------------|
| 1. DOMESTIC-U.S. AND ITS POSSESSIONS | <u>737</u> |
| 2. INTERNATIONAL (INCLUDING CANADA AND MEXICO) | <u></u> |

TOTAL TRAVEL 737

D. PUBLICATION AND DOCUMENTATION COSTS

TOTAL PUB COSTS 300

E. OTHER COSTS

| | |
|---|---------------|
| 1. Fellowship Stipend (review call for proposals) | <u>25,000</u> |
| 2. GSR Fees | <u>7,963</u> |
| 3. | <u></u> |
| 4. | <u></u> |
| 5. | <u></u> |
| 6. | <u></u> |

TOTAL OTHER COSTS 32,963

F. TOTAL DIRECT COSTS (A THROUGH E)

TOTAL DIRECT COSTS 44,500

G. INDIRECT COSTS

| | | | | |
|------------|--------------|----|---------------|--------------|
| ON CAMPUS | <u>25.0%</u> | OF | <u>19,500</u> | <u>4,875</u> |
| OFF CAMPUS | <u></u> | OF | <u></u> | <u></u> |

TOTAL INDIRECT COSTS 4,875

H. TOTAL COSTS

TOTAL COSTS 49,375

Prepared by: Philip Sandstrom

Phone: 803-466-3172

Fax: 530-754-9364

Admin

Contact: Jenny Nickell

Phone: 530-754-7155

Fax: 530-754-9364

YEAR 2 Start Date: 9/1/2009 (mm/dd/yy) End Date: 8/31/2009

PROJECT NUMBER
University of California Davis
INSTITUTION

A. Peter Klimley
NAME OF MENTOR
Philip Sandstrom
NAME OF FELLOW

CALFED FUNDS

A. EXPENDABLE SUPPLIES AND EQUIPMENT

| | |
|---|-------------------|
| 1. 30 Vemco V16 coded tags @ \$315.00/tag | <u>9,450</u> |
| 2. Surgical Supplies | <u>250</u> |
| 3. Boat fuel and maintenance | <u>500</u> |
| 4. | <u> </u> |
| 5. | <u> </u> |

TOTAL SUPPLIES 10,200

B. PERMANENT EQUIPMENT

| | |
|----|-------------------|
| 1. | <u> </u> |
| 2. | <u> </u> |
| 3. | <u> </u> |
| 4. | <u> </u> |
| 5. | <u> </u> |

TOTAL EQUIPMENT

C. TRAVEL

| | |
|--|-------------------|
| 1. DOMESTIC-U.S. AND ITS POSSESSIONS | <u>639</u> |
| 2. INTERNATIONAL (INCLUDING CANADA AND MEXICO) | <u> </u> |

TOTAL TRAVEL 639

D. PUBLICATION AND DOCUMENTATION COSTS

TOTAL PUB COSTS 300

E. OTHER COSTS

| | |
|---|-------------------|
| 1. Fellowship Stipend (review call for proposals) | <u>25,000</u> |
| 2. GSR Fees | <u>8,361</u> |
| 3. | <u> </u> |
| 4. | <u> </u> |
| 5. | <u> </u> |
| 6. | <u> </u> |

TOTAL OTHER COSTS 33,361

F. TOTAL DIRECT COSTS (A THROUGH E)

TOTAL DIRECT COSTS 44,500

G. INDIRECT COSTS

ON CAMPUS 25.0% OF 19,500
OFF CAMPUS OF

4,875

TOTAL INDIRECT COSTS 4,875

H. TOTAL COSTS

TOTAL COSTS 49,375

DATE:

Prepared by: Philip Sandstrom

Administrative Contact: Jenny Nickell

CUMULATIVE BUDGET

| | |
|--|-------------------------|
| <u>PROJECT NUMBER</u> | <u>A. Peter Klimley</u> |
| University of California Davis | <u>NAME OF MENTOR</u> |
| <u>INSTITUTION</u> | <u>Philip Sandstrom</u> |
| | <u>NAME OF FELLOW</u> |
| | CALFED FUNDS |
| A. EXPENDABLE SUPPLIES AND EQUIPMENT | 20,700 |
| B. PERMANENT EQUIPMENT | |
| C. TRAVEL | |
| 1. DOMESTIC-U.S. AND ITS POSSESSIONS | 1,376 |
| 2. INTERNATIONAL (INCLUDING CANADA AND MEXICO) | |
| D. PUBLICATION AND DOCUMENTATION COSTS | 600 |
| E. OTHER COSTS | 66,324 |
| F. TOTAL DIRECT COSTS (A THROUGH E) | 89,000 |
| G. INDIRECT COSTS | 9,750 |
| H. TOTAL COSTS | 98,750 |

I will assess the success and movement patterns of wild and hatchery adult and juvenile steelhead trout in the Sacramento River watershed from Redding, CA to the Golden Gate Bridge. I will examine the movements and success rates of wild and hatchery migratory steelhead trout in specific reaches throughout the Sacramento River, Delta, and San Francisco Estuary. By tagging both wild and hatchery fish it will be possible to compare differences in reach specific rates of survival and movement for juveniles and adults. With this data I can distinguish the performance of hatchery fish compared to the performance of wild fish over multiple years throughout the watershed. It will be possible to determine if they experience similar rates of mortality in the same stretches of rivers, have similar migratory rates, and the same response to environmental and anthropogenic changes. I will couple this data with my manual tracking data to complete the picture of juvenile steelhead trout behavior as they migrate to sea. Specific environmental and anthropogenic factors affecting juvenile success and movement will also be identified.

I believe that my research questions are closely aligned with CALFED goals and objectives, directly relating to several of CALFED's priority topic areas. My examination of steelhead trout responses to changes in the environment and factors affecting the success of juvenile and adult populations can provide essential data for scientists, researchers and agencies responsible for fish management. Using the automated monitor array deployed throughout the watershed it's possible to assess steelhead trout habitat through reach specific rates and relocation of individuals with a mobile receiver. It's also possible to demonstrate how changing flows and temperatures in the upper Sacramento River and Delta affect the timing of departure, migratory success, and route selection of steelhead trout. The data from the automated monitor will provide a direct measure of performance of steelhead trout in response to a host of measured environmental variables, habitat type, and route selection.

In addition this project will be completed in collaboration with several eminent scientist in the area based at different organizations such as UC Davis, UC Santa Cruz, NMFS, USFWS Red Bluff, USACE and potentially other groups. This project will use empirical field data to develop models that will be useful for managers and mitigation decisions.

Understanding the differences between the behavior and success of wild and hatchery fish is crucial for the sustainability and recovery of this once prolific stock. Do we risk dooming the remnants of remaining wild stocks by basing management and mitigation decisions on the behavior of hatchery fish alone, rather than seeking understanding of the unique behaviors and habitat needs of wild fish? To date it is unknown whether wild juveniles have higher success rates than hatchery fish, or if there is a higher proportion of repeat spawners in adult wild populations than hatchery adult populations. The collection of this data will be important for future mitigation actions for steelhead trout within the Central Valley and management of the species.

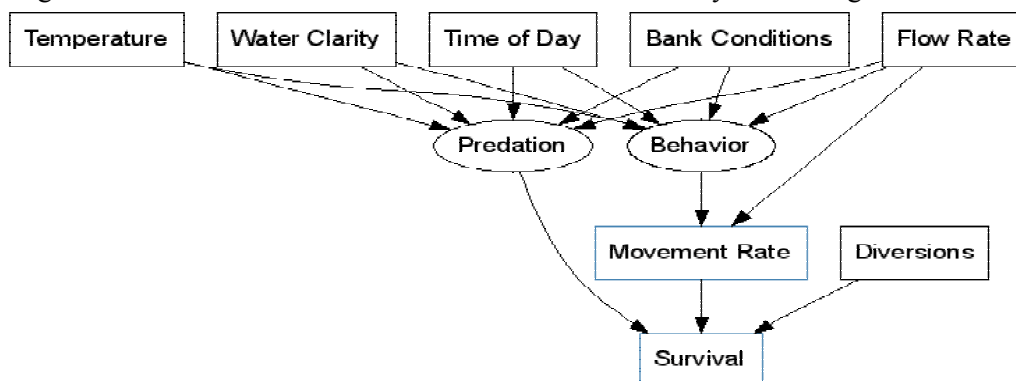


Fig. 1: Conceptual model of factors affecting migratory movements and success of steelhead trout. These factors will be evaluated to determine the response of adult hatchery, adult wild, juvenile hatchery, and juvenile wild steelhead trout.

I am interested in researching population dynamics in fish. Throughout my academic career, I have studied ecology, marine science, fisheries science, physical processes, animal behavior, statistics and modeling. I have also participated in a variety of research-based internships. Through both my academic studies and internship experiences, I have tried to improve myself as a scientist, particularly by acquiring the knowledge and skills that would enable me to address important theoretical questions.

Funding by CALFED will greatly enhance my inquiry into the life history and behavior of Central Valley steelhead trout. CALFED support would allow me to study both adult and juvenile phases of this endangered species, as well as to provide comparative analyses of steelhead raised in a hatchery versus those reared in the wild. Previous studies of steelhead trout have had a relatively narrow focus, varying from examinations of the physiological responses of a single species to research concentrating on ecological function. My research, which focuses on fish behavior and population dynamics, will extend existing studies by adding an additional life stage of the fish to my study to help complete the picture. My research will also draw upon knowledge and skills that I have acquired through a variety of pertinent experiences, including studies I have conducted as a part of a CALFED-funded project at UC-Davis.

I have participated in significant research endeavors in Wisconsin, Florida, and Maryland. In 2004, I was one of eight students to serve a summer as a NSF REU at the University of Milwaukee's WATER Institute. My project involved researching the predator/prey interactions of round gobies and two predator species, smallmouth bass and largemouth bass. I was primarily concerned with examining the differences in consumption rates of each predatory species in three different environmental settings—rocky, weedy, and rocky/weedy. This research stemmed from observation of smallmouth bass coexisting with round gobies in rivers on the eastern side of a lake and smallmouth bass in the absence of round gobies on the western side of the lake in the same river. Largemouth bass were present in the heavily vegetated lake, but no round gobies were found in the lake. My hypothesis was that the largemouth bass were acting as a “bio-barrier” rather than smallmouth bass predating on round gobies in the river on the western side of the lake but not the eastern side. Experimental results appeared to support this hypothesis with largemouth bass and smallmouth bass consuming on average three and one round goby per trial. We also used Wisconsin Department of Natural Resources data on a lagoon connected to Lake Michigan which suggested the displacement of smallmouth bass and increase of largemouth bass within the lagoon as round gobies increased over a period of years. During my time at the WATER Institute I gained skills in experimental manipulation, observational data collection, statistical analysis and working as part of a scientific team.

In 2005, I assisted in a mark-recapture study of sharks in the middle Florida Keys conducted by the Center for Shark Research at Mote Marine Laboratory. Using long line survey sampling at a variety of study sites throughout the Middle Florida Keys, we examined the distribution and seasonal assemblages of all elasmobranch species through the use of roto and dart tags. Captured individuals were measured, sexed, and genetic samples were taken. This data was entered into our data base and plotted in GIS with general habitat layers. Through this process we determined where species, sexes, and size classes were captured/recaptured in relation to habitat and season.

Following my research in Florida, I worked at the University of Maryland's Chesapeake Biological Laboratory studying white perch. My primary responsibility was to design and conduct field and laboratory experiments focusing on growth rates of young white perch in response to environmental variables such as temperature, salinity, and dissolved oxygen. I monitored the growth rates in the wild, as well as growth, egestion, and respiration rates under laboratory manipulations.

My latest research involves the study of Central Valley salmonids using acoustic telemetry, a CALFED-funded project at UC Davis. For the past two years I've been researching the migratory success of juvenile hatchery chinook salmon and steelhead trout, examining the

outmigratory success and behavior of juvenile salmonids. This research has been completed through the use of automated monitors along with manual tracking of juvenile steelhead trout. The first deployment of the automated monitor array was in 2006.

In addition to the automated tracking, I have manually tracked juvenile steelhead tagged with pressure-sensing tags. I tracked these individuals continuously for five days recording the depth and GPS of the fish every three seconds while recording bottom depth, temperature, salinity, and dissolved oxygen. This data has been used to examine the fine-scale movements and depth distribution of juvenile steelhead to extend the data collected by the automated monitors. The manual track data provided important information about behavioral responses of these fish not possible with the automated monitor array. By manually tracking individual steelhead trout, we noted the strong response of these fish to tidal flows within the Delta. Several of the fish tracked in the Delta were observed moving with the tidal flow when in the upper two meters of the water column, but then moved to the bottom of the water column (making small non-directed movements) until the tide switched. On four successive tides, one fish was observed changing direction of movement within 15 minutes of the change in direction of tidal flow.

This groundbreaking research has afforded me the opportunity to provide technical advice and support to several of our collaborative research partners. Further, because of my extensive field experience, I was invited to conduct experiments on the range of acoustic tags under different environmental conditions, as well as tag retention studies. Since the fish require surgery to implant the tags, I have written the IACUC animal care protocol for the project. Another large portion of my responsibility involves overseeing the budget and training of new members in the biotelemetry laboratory.

In addition to my academic and research experience, I have attended technical training seminars to improve my mark-recapture and analytical skills. In August, 2007 I spent a week at Colorado State University to learn Program MARK, a software program useful for creating detection and survival programs with many models such as the Cormack-Jolly-Seber and Multi-strata models. Use of this program can help determine optimal release strategies and necessary numbers of individuals to accurately construct survival and detection probabilities. I have also taken staff training in Microsoft Excel and Access and have become proficient in database management and queries. My graduate courses in Matlab programming and GIS have also contributed greatly to my technical skills. I have also presented numerous posters and oral presentations at state, national, and international conferences.

As a Ph.D. student in the Ecology program, I will continue to develop my analytical and experimental skills at the University of California-Davis. I believe that my academic work, technical training, and research experience has more than adequately prepared me to conduct the proposed research. I am part of a dedicated and skilled scientific community as a member of the University of California-Davis, the Biotelemetry Laboratory, and California Fish Tracking Consortium. I also have the benefit of receiving the support, advice and knowledge of a wide array of colleagues and mentors. Finally, my passion for understanding fish, along with my commitment to their preservation, means that I will be tireless in pursuing scientific knowledge that can enhance their long-term survival in the face of myriad threats.

Phil Sandstrom
ptsandstrom@ucdavis.edu

University of California Davis
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(530) 754-5351
(803) 466-3172

Oral and Poster Presentations

Sandstrom, P.T., A. J. Ammann, E. D. Chapman, A. P. Klimley, R. B. MacFarlane, S. Lindley and C. J. Michel. 2008. *Fine-Scale Movement and Depth Distribution of Juvenile Steelhead Trout in the Sacramento River and San Francisco Bay Estuary*. Oral Presentation. Auckland, New Zealand. Advances in Fish tagging and Marking Technology.

Sandstrom P. T., A. J. Ammann, A. P. Klimley, R. B. MacFarlane, S. Lindley, E. D. Chapman, C. J. Michel and T. E. Pearson. 2007. *Fine-scale movement and depth distribution of steelhead in the Sacramento River and San Francisco Bay*. Oral Presentation. San Francisco, CA. American Fisheries Society 137th Annual Meeting. Thinking Downstream and Downcurrent: Addressing Uncertainty and Unintended Consequences in Fish and Fisheries.

Sandstrom P. T., A. J. Ammann, A. P. Klimley, R. B. MacFarlane, S. Lindley, E. D. Chapman and C. M. Michel. 2007. *Fine-scale movement and depth distribution of steelhead in the Sacramento River and San Francisco Bay*. Poster. Oakland, CA. A Greener Shade of Blue: 8th Biennial State of the San Francisco Estuary Conference.

Sandstrom, P. T., A. J. Ammann, L. L. Schlipp, A. P. Klimley and R. B. MacFarlane. 2006. *The range of detection of coded ultrasonic tags by automated monitors in the Sacramento/San Joaquin Watershed*. Poster. Sacramento, CA. 4th Biennial CALFED Bay-Delta Program Science Conference.

Ammann, A. J., **P. T. Sandstrom**, E. D. Chapman, C. Michel, A. P. Klimley, R. B. MacFarlane and S. Lindley. 2007. *The performance of V7, V9, and V16 transmitters and VR2 receivers under varying environmental conditions*. Poster. Oakland, CA. A Greener Shade of Blue: 8th Biennial State of the San Francisco Estuary Conference.

Chapman E. D., **P. T. Sandstrom**, Ammann, A. J., C. Michel, A. P. Klimley, R. B. MacFarlane and S. Lindley. *Diel migrations of salmon smolts in the Sacramento River, Delta, and San Francisco Bay Estuary*. 2007. Poster. Oakland, CA. A Greener Shade of Blue: 8th Biennial State of the San Francisco Estuary Conference.

MacFarlane, R. B., A. P. Klimley, Ammann, A. J., **P. T. Sandstrom**, S. Lindley and E. D. Chapman. 2007. *Survival and migratory patterns of Central Valley juvenile salmonids: Overview*. Poster. Oakland, CA. A Greener Shade of Blue: 8th Biennial State of the San Francisco Estuary Conference.

Michel, C. J., A. J. Ammann, S. Lindley, **P. T. Sandstrom**, E. D. Chapman, A. P. Klimley and R. B. MacFarlane. 2007. *Acoustically monitored movement patterns of juvenile chinook salmon (Oncorhynchus tshawytscha) from the Sacramento River Watershed during a low flow year*. Poster. A Greener Shade of Blue: 8th Biennial State of the San Francisco Estuary Conference.

MacFarlane, R.B., A. P. Klimley, S. Lindley, A. J. Ammann, **P. T. Sandstrom**, C. J. Michel, and E. D. Chapman. 2008. *Migration and Survival of Juvenile Salmonids in California's Central Valley and San Francisco Estuary*. Oral Presentation. Auckland, New Zealand. Advances in Fish tagging and Marking Technology.

MacFarlane, R. B., A. P. Klimley, S. Lindley, A. J. Ammann, **P. T. Sandstrom**, E. D. Chapman, C. J. Michel and T. E. Pearson. 2007. *Juvenile salmonid movement patterns and survival in the Sacramento River and San Francisco Bay from acoustic tagging*. Oral Presentation. San Francisco, CA. American Fisheries Society 137th Annual Meeting. Thinking Downstream and Downcurrent: Addressing Uncertainty and Unintended Consequences in Fish and Fisheries.

I am currently organizing a special oral session and poster cluster for the California Fish Tracking Consortium at the 2008 5th Biennial CALFED Conference in addition to presenting my own poster and oral presentation.

Course Work

In Progress – Ph.D. in Ecology University of California Davis

Principles and Application of Ecological Theory
Theoretical Ecology
Mathematical Methods in Population Biology
Multivariate Statistics
Synchrony
Introduction to GIS- audited
Applied Conservation- audited
Population Genetics Data Analysis
Carnivore Conservation

B.S. in Marine Science University of South Carolina GPA 3.817 Collegiate GPA 3.597

Biology I & II
Chemistry I & II
Calculus I & II
Physics I & II

Organic Chemistry I & II
Physical Geology
Genetics
Animal Behavior
Wildlife Ecology and Management
Environmental Issues
Ecology and Evolution
Oceanography
Physical and Chemical Oceanography
Evolutionary Marine Environment
Processes in the Marine Environment
Biology of Marine Organisms
Marine Ecology
Ichthyology
Marine Plants
Aquatic Chemistry
Ocean Data Analysis
Statistical Methods

Technical Training

Throughout my college career I have developed skills in the utilization of Excel, Access, Oriana, JMP, GIS, Program MARK, and Matlab computer programs. I have taken staff training courses in Microsoft Excel and Access, audited a course and worked with GIS, taken a semester long course on analyzing and writing code in Matlab and a quarter long course which heavily used JMP. I also attended a workshop on Program MARK at Colorado State University from the creators of the software. I have also gained skills in database management.

I am also open water dive certified, have spent considerable time on large research vessels at sea, spent a great deal of time working out of small boats in the river, estuary, and ocean. I have experience running boats in shallow rivers.

Experience

University of California Davis Biotelemetry Laboratory and California Fish Tracking Consortium:

While at the UCD I have worked as a lead on the juvenile chinook and steelhead trout project. This work focuses on the migratory success and behavior of juvenile salmonids. For this project I have been involved in the tagging of fish and deployment of an acoustic array in the Sacramento River Watershed. As part of this project we have conducted several technical inquiries such as tag retention studies, acoustic monitoring experiments, and range tests of automated monitors. In addition I have started and worked on other side projects involving assessment of fine scale movements and behaviors of juvenile steelhead and oceanic movements of steelhead trout kelts. In my position at UCD I have been expected to develop my analysis, dissemination, management, and field technique

skills. I have been involved in advising many other acoustic telemetry projects in the Central Valley. I have also completed data analysis and given several oral presentations and posters at local, national, and international symposia. In addition to my research responsibilities I have taken several courses to increase my study design, data analysis, and modeling skills such as mathematical population biology, multivariate statistics and theoretical ecology.

A. Peter Klimley
University of California Davis
One Shields Ave.
Davis, CA 95616
530-752-5830
apklimley@ucdavis.edu

University of Maryland Center for Environmental Science-Chesapeake Biological Laboratory:

During my time at CBL I assisted with several different projects and research cruises. I helped with weekly seining, bluefish cruises which entailed fish identification and measurements, and Hudson River telemetry. In addition I was the lead on a white perch growth egestion experiment. This research involved temperature and salinity manipulations to determine the impact of these variables on growth and egestion of white perch. White perch respiration rates were also measured at varying salinities and temperatures. This project also entailed a field component by monitoring fish held in mesocosms at various locations along the Patuxent River, and ¼ acre ponds at Horn Point Laboratory were also stocked with white perch to monitor growth rates with varying salinity and temperature.

David H. Secor, Professor
UMCES - Chesapeake Biological Laboratory
1 William St., Solomons, MD 20688

Mote Marine Laboratory at the Center for Tropical Research-Center for Shark Research:

While at the Mote Marine Laboratory site on Summerland Key I assisted with a shark survey of the mid to lower keys. Much of my time was spent in the field for this project. I assisted with the collection of DNA from Nurse, Blacktip, and Great Hammerhead sharks. We tagged all species of sharks we captured and recorded sex, took length measurements of the sharks, as well as weighing sharks of appropriate size. We made long line and drum line sets recording their positions on GPS and water conditions using a YSI. This data was entered into a database and then appropriate data was transferred into GIS as a layer. This data used in the GIS system was used to create a map of where each shark was captured as well as which species. This allowed us to look at the distribution of different species and sexes with respect to seasonality and habitat type. I

repaired our gear and helped with the care and monitoring of our captive nurse sharks. In addition I participated in two of Mote's week long shark tagging trips.

Harold "Wes" Pratt
Adjunct Scientist
24244 Overseas Highway
Summerland Key, FL 33042
(305) 745-2729 Ext. 201
(305) 744-0067
pratthwes@cs.com

**Great Lakes Wisconsin Aquatic Technology and Environmental Research
(WATER) Institute:**

I was selected as a NSF REU student and conducted research at the WATER Institute on largemouth and smallmouth bass predation on round gobies in different habitats. During this process I maintained the tanks and fish, as well as collecting specimens for the trials. I also observed largemouth and smallmouth bass in wild habitats with round gobies to monitor their natural behavior. I observed the bass during the trials and performed counts to monitor their consumption rates during controlled experiments in which habitat type was manipulated. I also recorded the trials for additional review to quantify the different avoidance techniques and trends of round gobies in different habitat types and in the presence of different predatory species (smallmouth bass and largemouth bass). In addition to the above tasks, I also assisted with sculpin diet and age analysis and mysid density counts. I also went on several cruises which enabled me to learn how to sample with ponar grabs, niskin bottles, CTD, and how to use a sonar/GPS system on a research vessel.

John Janssen
Senior Scientist
600 East Greenfield Ave.
Milwaukee, WI 53204
(414) 382-1733
jjanssen@uwm.edu

University of South Carolina Lab Work:

My responsibilities in this lab included getting information about parts for development of a new instrument, building casings for equipment, and acid washing sample bottles and equipment. I also help make the beads that we used to measure rare earth elements in estuarine waters being tested.

Timothy J. Shaw
Dept. of Chemistry & Biochemistry
631 Sumter St.

Columbia, SC 29208
(803) 777-0352
shaw@mail.chem.sc.edu

Field Studies at Baruch Institute:

During this course, I spent three weeks at the Baruch Institute in Georgetown, SC learning valuable techniques to sample and analyze data from a salt marsh. I sampled nekton using traps, bag seines, otter trawls, and trammel net. Benthic fauna was sampled by coring, grab sampling, and dredging transects. I learned how to use CTDs and ADCPs. I also sampled phytoplankton and zooplankton. All the data collected was used to develop an ecological overview of North Inlet Estuary.

Richard Zingmark
Dept. of Marine Science
601 Earth and Water Sciences
(803)777-4873
zingmark@biol.sc.edu

National Aquarium in Baltimore:

During this three month internship, I worked full-time under the guidance of my mentor. I learned valuable skills and performed daily tasks. I maintained and cleaned the tanks in the backup area of the gallery and monitored the main exhibits of my mentor's gallery. I prepared the food and medications for the morning and afternoon feeds as well as performing water changes and backwashes on the sand filters of exhibits. I also helped prepare long lines for collection trips, assembled backup tanks, helped with acclimating new specimens, and assisted with other galleries and the warehouse as needed.

Keri O'Neil
Aquarist
501 East Pratt St
Baltimore, MD 21202
(410) 986-2378
KO'Neil@aqua.org

Plan for Collaborating with Community Member:

I plan to have Joe Merz, Ph. D. of Cramer Sciences as a community mentor. He has agreed to serve as my community member for this project. Dr. Merz is a fisheries biologist with interests similar to my own. He is experienced with telemetry work and started the steelhead trout telemetry project on the Mokelumne River. He is also knowledgeable in modeling and software programs. In addition he has been working with salmonids in the Central Valley for more than 15 years. I feel that he would bring a great deal of technical expertise and academic/practical knowledge to the project. Dr. Merz's years of field experience in other river of the Central Valley will help guide the plans of the project. Dr. Merz has vehicles and boats at his disposal which could be useful for the project. This would nicely compliment the small fleet of boats the Biotelemetry Laboratory at UC Davis utilizes to work under various river and bay conditions as dictated by the work and conditions. This would also make any necessary work in the bay easier as we would not need to trailer boats from UC Davis to do the work, and would supplement the travel and boat costs that would be incurred.

While working with East Bay Municipal Utilities District Dr. Merz was able to capture and tag wild steelhead trout. He also assisted UC Davis with downloading of Delta acoustic monitors by coming out in the field. Dr. Merz made boat time for monitor downloads and staff available for manual tracking of steelhead trout. Collaboration on this research project concerning adult steelhead trout would further strength ties between our groups and increase my support network. It would also be a good way to lead to future collaborations with Dr. Merz and potentially other researchers at Cramer Sciences.

This collaboration would be useful for both Dr. Merz and myself, as well as the CALFED community. The data collected from an acoustic telemetry project on adult steelhead trout would yield detailed data concerning reach specific rates of survival and movement, timing, response to environmental cues, and trends or patterns of behavior. I believe that the expertise of Dr. Merz would lead to better data analysis and the development of new hypotheses for future studies. His knowledge of salmonids habitat use and spawning will be essential analysis of the success and proportion of iteroparous steelhead trout while considering environmental variables. Dr. Merz also has a record of publication and would assist in creating presentations and publications in peer reviewed journals.

I believe that Dr. Merz is a good choice as a community mentor as he has worked in the Central Valley for the past 18 years. He is very enthusiastic about his research and has a strong background in work concerning salmonids. In addition he has experience working with CALFED and is familiar with mentoring CALFED fellows. My prior experiences with Dr. Merz would lead me to believe that he has a wealth of knowledge and expertise.

CALFED Project Summary Form - California Sea Grant

Title: Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks

Type of Fellowship: Predoctoral

Initiation Date: 09/01/2008

Completion Date: 08/31/2010

| | Last | First | Initial | |
|----------------------------|---------------------------------|----------|---------|---------------------|
| CALFED Fellow: | Sandstrom | Philip | | Effort: |
| Affiliation: | University of California, Davis | | | Affil. Code: |
| Research Mentor 1: | Klimley | A. Peter | | Effort: |
| Affiliation: | University of California, Davis | | | Affil. Code: |
| Research Mentor 2: | | | | Effort: |
| Affiliation: | | | | Affil. Code: |
| Community Mentor 1: | | | | Effort: |
| Affiliation: | | | | Affil. Code: |
| Community Mentor 2: | | | | Effort: |
| Affiliation: | | | | Affil. Code: |

Total CALFED Funds: 98,750

Related Projects:

Parent Projects:

Key Words:

Objectives:

1. Characterize the movements of adult wild and hatchery steelhead trout.
2. Characterize the movements of juvenile wild and hatchery steelhead trout.
3. Determine behavioral and success* differences between adult hatchery and wild (completed in the same fashion from data on another CALFED funded grant in collaboration with California Fish Tracking Consortium).
4. Determine behavioral and success* differences between juvenile hatchery and wild (completed in the same fashion from data on another CALFED funded grant in collaboration with California Fish Tracking Consortium).
5. Determine differences among the rates of iteroparity (repeat spawning) in adult hatchery and wild steelhead trout.
6. Assess the impact of specific environmental and anthropogenic effects on steelhead trout.
7. Create a model to determine the contributions of wild and hatchery stocks of both adults and juveniles based on success rates and environmental conditions.

*Success is measured rather than mortality to avoid issues of tag shedding, mortality, or tag malfunctions.

Methodology:

I propose to use the extensive array currently in use by researchers at UC-Davis that was developed for the California Fish Tracking Consortium, a CALFED funded project, to study the migratory behavior of both wild and hatchery steelhead trout. I will implant 15 wild adult steelhead trout, 15 adult hatchery steelhead trout with acoustic tags in 2008/2009 and 2009/2010. In addition I will 200 juvenile wild steelhead trout, and 300 juvenile hatchery steelhead trout with acoustic tags in 2008/2009 another CALFED funded study.

The development of miniature tags and automated listening stations makes acoustic technologies more applicable to salmonids. Use of this acoustic technology makes it possible to answer many more questions about the movements and reach specific rates of fish than has been previously possible with any other previous technology. In addition, Vemco's creation of a line of low cost acoustic tags and automated monitors has made such a study cost effective. The proposed study fits within the category of a mark-recapture study, but the fish are never touched after the surgical procedure and subsequent release, thereby minimizing the effect of handling on tagged fish.

The Sacramento River Watershed presents a unique opportunity because of a large infrastructure of acoustic monitors deployed from Redding, CA to the continental shelf break just north of San Francisco, CA. In all there are more than 200 acoustic monitors deployed throughout the study region. In the river monitors are deployed in pairs to prevent data loss and improve detection. In the San Francisco Bay Estuary we have deployed curtain lines at several choke points to ensure the detection of tagged fish. These lines have been deployed at Rio Vista, Jersey Point, Chipps Island, Benicia Bridge, Carquinez Bridge, San Rafael Bridge, Racoon Strait, and the Golden Gate Bridge. Since the water is deep and fast moving at the final detection point before fish reach the Pacific Ocean near the Golden Gate, the curtain line has been deployed as a double and staggered array to ensure passing fish are detected.

In Fall/Winter of 2008 I will tag 15 returning wild adult steelhead trout, and 15 hatchery adult steelhead trout returning to Coleman National Fish Hatchery with Vemco V16 tags which have a tag life of five years. Wild steelhead trout will be captured through hook and line sampling, long lining, and gill netting in necessary to tag the proposed 20 fish. The Biotelemetry Laboratory has experience successfully hook and line sampling for steelhead trout and gill netting and tagging green sturgeon. We also work with other groups that have caught and tagged adult wild steelhead trout. The captured fish will be anesthetized and implanted with acoustic tags and monitored briefly following the surgical procedure to ensure the surgery was a success. We have extensive experience tagging fish while on the river, in the laboratory and at the hatchery and have developed specialized surgical tables to minimize stress to fish during the procedure. Vemco V16 tags that with a tag life of five years will be implanted into all tagged fish. The V16 tag is an optimal tag size (<5% of fish body weight) for adult steelhead trout, has an appropriate tag life, and has a greater detection range than the V7, V9, and V13 tags which will increase our detection probability. The hatchery steelhead will come from Coleman National Fish Hatchery. These fish will also be tagged with V16 for the earlier reasons mentioned. The hatchery fish will be starved for 24 hours prior to surgery and anesthetized with MS-222. Once the fish are anesthetized they are moved to the surgical table where a pump pushes a flow of water containing a low concentration of MS-222, keeping the fish fully anesthetized throughout the surgical procedure. A small incision is made near the mid ventral line in front of the pelvic girdle. The ultrasonic tag is then implanted into the peritoneal cavity of the fish. The incision is closed with two square knots and excess material is cut off, leaving a clean, closed incision. The fish is placed in a recovery tank and observed until it makes a full recovery. During the surgical procedure data is collected on the weight, length, and condition of the fish (eyes, fins, and scales). In addition, a photo and genetic sample is taken from each fish. The protocol for wild fish surgery will be the same, with the exception of not being starved 24 hours prior to surgery and CO2 will be used as an anesthetic rather than MS-222 so there will be no required holding period.

In addition to data on fish movement we will collect temperature data from temperature loggers attached to the automated monitors and examine other sources of environmental data such as CDEC and USGS stations throughout the river, delta and estuary. The data will be analyzed in program MARK to determine success and detection probabilities for wild and hatchery fish.

Rationale:

Researchers know little about the migratory movements and success of hatchery steelhead trout. They know even less about wild steelhead trout. This lack of knowledge is troubling because steelhead trout is an important and iconic species in the Central Valley. Considered a significant community resource, the preservation of this species is of vital concern to a broad spectrum of interests. The knowledge gained from the proposed project will lead to better management and mitigation of steelhead trout, facilitating the recovery of the species and increasing our knowledge of its current status and the threats it faces. It

is crucial to understand the differences between hatchery and wild stocks in the Sacramento River so that we can determine the best management practices for enhancing the future survival of all life histories and stages of steelhead trout.

The proposed research will also enable us to outline key environmental and anthropogenic variables for hatchery and wild fish. Moreover, it would allow us to differentiate the contribution of hatchery and wild stocks to overall numbers. Drawing on this data, we could determine the impact/benefit of hatchery fish released into the system.

Anticipated accomplishments:

Reports will be written throughout the course of the project as requested. At the end of year one results of the study will be presented at the biennial CALFED conference. After year two, when the study has been completed, the results will be presented at the CALFED conference and possibly the annual American Fisheries Society meeting. The data from the entire study will be analyzed and submitted for publication in a peer reviewed journal. We will also write a final report for CALFED and distribute our results and findings to appropriate managers.



DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
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6 May 2008

Ms. Shauna Oh
California Sea Grant
9500 Gilman Dr., #0232
La Jolla, CA 92093-023

Dear Ms Oh:

I am the Major Professor overseeing the graduate studies of Mr. Phillip Sandstrom within the Ecology Graduate Group of UC Davis. He is a very active and productive member of my Biotelemetry Laboratory. This letter is to indicate my willingness to provide intellectual guidance to him while he is supported by a CALFED Fellowship to conduct the studies described in his proposal, entitled "Sacramento river trout: an assessment of behavioral differences and contributions of wild and hatchery stocks." I have reviewed the proposal, provided him constructive criticism, and support its contents wholeheartedly. Bruce MacFarlane, a Senior Scientist at the National Marine Fisheries Service, and I are joint Principle Investigators on a CALFED contract, entitled "Survival and migratory patterns of Central Valley salmonids." We have tagged and released 200 hatchery-raised steelhead smolts during January 2007 and 300 smolts during January 2008 into the Sacramento River, and recorded reach-specific rates of movement and survival throughout the river, the Delta, and the San Francisco Estuary. An additional 75 steelhead smolts were released at the head of the Delta over the same period during 2008 and 150 during 2008 to determine the percentage of smolts entering the Cross-Delta Canal versus continuing downstream within the mainstem of the river under the direction of Ms. Pat Brandes of the US Fish and Wildlife Service. Phil has assumed a strong leadership role in both studies, and will have access to the tag-detections from these two studies as well as access to the tag-detections of the 300 hatchery raised steelhead and 300 wild steelhead, which will be released in the Sacramento River and its tributaries during January 2009.

Phil is proposing to expand this study by tagging and monitoring reach-specific rates of survival of steelhead adults tagged within the river, and the longevity of the tags (5-10 years) will enable him to estimate their survival in the river during their outmigration, their migration throughout the ocean, and during their upmigration. He will also have access to the tag-detection records for approximately 20 steelhead trout double tagged with archival and coded ultrasonic tags that he and Steven Teo, a Postdoctoral Fellow in our department, placed on adult steelhead during March 2008.

Phillip is a very outstanding student, and the fellowship will enable him to perform some ground-breaking research.

Cheers,

A. Peter Klimley, Ph.D.
Adjunct Professor
Director, Biotelemetry Laboratory

(ABBOTT) PETER KLIMLEY

Professional Address

DIRECTOR
BIOTELEMETRY LABORATORY
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EDUCATION

- 1982 Doctor of Philosophy (Ph.D.), Marine Biology.
 Scripps Institution of Oceanography, UC San Diego, California.
 Dissertation: Social organization of schools of scalloped hammerhead sharks, *Sphyrna lewini* (Griffith and Smith), in the Gulf of California.
 Committee: Bradbury, J., W. Evans, W. Heiligenburg, D. Nelson, and R. Rosenblatt (Chairman).
- 1976 Master of Science (M.Sc.), Biological Oceanography.
 Rosenstiel School of Marine and Atmospheric Science, University of Miami, Coral Gables, Florida.
 Thesis: Analysis of acoustic stimulus properties underlying withdrawal in adult lemon sharks, *Negaprion brevirostris* (Poey).
 Chairman: Myrberg, Jr., A.
- 1970 Bachelor of Science (B.S.), Zoology.
 State University of New York, Stony Brook, New York.

EMPLOYMENT

- 2008-Pres. Adjunct Professor, Department of Wildlife, Fish, & Conservation Biology,
 University of California, Davis.
- 2003-2008 Adjunct Associate Professor, Department of Wildlife, Fish, & Conservation
 Biology, University of California, Davis.
- 2001-2002. Senior Fisheries Ecologist, H.T. Harvey & Associates, San Jose.
- 1996-2002 Associate Research Behaviorist, Bodega Marine Laboratory, UC Davis.
- 1987-1995 Assistant Research Behaviorist, Bodega Marine Laboratory, UC Davis.
- 1984-1987 Assistant Research Scientist, Scripps Institution of Oceanography, UC San Diego.

- 1982-1984 Postgraduate Researcher, Scripps Institution of Oceanography, UC San Diego.
- 1977-1982 Graduate Research Assistant, Scripps Institution of Oceanography, UC San Diego, Office of Naval Research (ONR) Contract: Field behavior of sharks, Principal Investigator: Nelson, D.
- 1973-1976 Research Assistant, Graduate Department, Rosenstiel School of Atmospheric Science, University of Miami, ONR Contract: Acoustic behavior of sharks, Principal Investigator: Myrberg, Jr., A.

ADJUNCT FACULTY / RESEARCH ASSOCIATE

- 2007-Pres. Adjunct Associate Professor, Department of Biology, Clemson University, South Carolina.
- 2005-Pres. Research Associate, Watershed Center, John Muir Institute for the Environment, University of California, Davis.
- 1999-Pres. Adjunct Associate Professor, Department of Wildlife, Fish, & Conservation Biology, University of California, Davis.
- 1997-Pres. Research Associate, Institute of Marine Science, University of California, Santa Cruz.
- 1993-Pres. Adjunct Faculty Member, Centro de Investigaciones de Biologicas, La Paz, Mexico.
- 1991-Pres. Research Associate, Point Reyes Bird Observatory, Bolinas, California.

RESEARCH INTERESTS

Animal behavior and behavioral ecology of marine vertebrates

Conservation

Marine fisheries biology, ecology, and oceanography

Biotelemetry: development of behavioral and environmental sensors, computer-decoded telemetry, automated data logging, archival tags.

GRANTS/CONTRACTS (RECEIVED)

- 2008-2009 Studies of sevengill sharks in San Francisco Bay, Aquarium of the Bay, \$64,508.

- 2008-2010 The effect of *Egeria* on largemouth bass: telemetric pilot study, Interagency Ecological Program, \$201,585.
- 2008-2009 Research support, data analysis, and report preparation for LTMS salmonid tracking, US Army Corps, San Francisco, \$54,523.
- 2008-2009 Supplement: survival and migratory patterns of Central Valley juvenile salmonids, CALFED ERP Program, California, \$258,676 (with B. MacFarlane).
- 2007-2008 Tagging and tracking hammerhead sharks at the Galapagos Islands, Committee for Research and Exploration, National Geographic Society, \$10,000.
- 2007-2008 Tagging and tracking hammerhead sharks at the Galapagos Islands, Expeditions Council, National Geographic Society, \$10,000.
- 2007-2009 Sacramento river green sturgeon migration and population assessment, United States Bureau of Reclamation, \$113,000 (with B. May and J. Israel).
- 2007-2009 Tagging scalloped hammerhead, Galapagos, and whale sharks relative to reserve creation in the Galapagos Islands, World Wildlife Fund, \$50,000 (with A. Hearn).
- 2007-2009 Population biology, life history, distribution, and environmental optima of green sturgeon, Directed Action, California Fish & Game, \$969,691 (with J. Cech, S. Doroshov, and B. May).
- 2007-2008 Movements of Greenland sharks near the seal colony at Sable Island, Canada (with J. Kelly and S. Compans), Committee of Research and Exploration, National Geographic Society, \$30,000.
- 2005-2006 Biological Assessment of green sturgeon in the Sacramento-San Joaquin watershed, California Bay and Delta Authority, CALFED, California, Amendment, \$273,050 (with J. Cech, S. Doroshov, B. May, and I. Werner).
- 2005-2008 Survival and migratory patterns of Central Valley salmonids. CALFED ERP Program, California, \$1,500,000 (with B. MacFarlane).
- 2005-2008 Behavioral, physiological, and genetic studies of white sharks in the Gulf of the Farallones, Monterey Bay Aquarium, \$500,000 (with B. Block and H. Dewar).
- 2005-2006 Telemetric and Isotopic Studies of the Feeding Ecology of White Sharks at Guadalupe Island, Pflieger Institute for Marine Studies, \$35,000 (with F. Galvan-Magaña).
- 2004-2005 Determining the ecological importance of seamounts to pelagic fishes and fisheries in the Gulf of California, Science for Oceans and Coast, David and Lucile Packard Foundation, \$41,105.
- 2004-2006 Experimental and field studies to assess pulsed, water-flow impacts on the behavior and distribution of fishes in a Californian river, UC Stream Pulsed Flow Program, \$385,530 (with J. Cech and L. Thompson).

- 2003-2006 Biological Assessment of green sturgeon in the Sacramento-San Joaquin watershed, California Bay and Delta Authority, CALFED, California, \$1,266,893 (with J. Cech, S. Doroshov, B. May, and I. Werner).
- 2003-2004 Determination of population size and migratory corridor of hammerhead sharks and the conservation of the species in the Gulf of California, UC MEXUS, \$24,100 (with F. Galvan-Magaña).
- 2001-2003 Tracking hammerhead sharks for creation of marine reserves, Committee for Research and Exploration, National Geographic Society (NGS), \$38,788.
- 2001-2003 Biological Assessment of green sturgeon in the Sacramento-San Joaquin watershed, Anadromous Fish Research Program, CALFED, \$641,362 (with J. Cech, S. Doroshov, and B. May).
- 2000-2001 Environmental contaminants in great white shark (*Carcharodon carcharias*) in California, Morris Animal Foundation, \$6,446 (with K. Gilardi).
- 1999-2000 Predator-prey interactions in white sharks and elephant seals, Committee for Research and Exploration, National Geographic Society (NGS), \$17,000.
- 1998-2000 Development and implementation of transponding system to track the annual migration of fishes, National Undersea Research Program (NURP), \$83,741.
- 1997-1999 Automated monitoring of pelagic fish assemblage during El Niño/Southern Oscillation (ENSO), Biological Oceanography, NSF, \$49,989.
- 1997-1998 Optimization of sensors and geopositioning algorithms for archival tags, NURP, \$8,800.
- 1997-1998 Experimental study of geomagnetic topotaxis with elasmobranchs, Sensory Systems, NSF, \$43,735.
- 1997-1998 Playback of ATOC-type signal to bony and cartilaginous fishes to evaluate phonotaxis, Department of Defense (DOD), \$32,000.
- 1997-1999 Predator-prey interactions among white sharks and northern elephant seals, Animal Behavior and Multi-User Biological Equipment and Instrumentation, NSF, \$115,631, Co-PI: B. Le Boeuf, UC Santa Cruz.
- 1995-1998 Tracking of juvenile white sharks, Sea World-San Diego, \$119,958.
- 1995-1996 Publication of "Great White Sharks: The Biology of *Carcharodon carcharias*," Bodega Marine Laboratory, California Department of Boating and Waterways, David and Lucille Packard Foundation, Discovery Channel, Gulf of the Farallones National Marine Sanctuary, Monterey Bay National Marine Sanctuary, Natal Sharks Board, South Africa, National Audubon Society, PRBO International Biological Research, Primary

- Industries, Fisheries, South Australia, SARDI, Australia, Shark Research Institute, Princeton, \$17,900.
- 1994-1996 Experimental studies of geomagnetic topotaxis on scalloped hammerhead sharks, Animal Behavior and Sensory Systems, NSF, \$80,000.
- 1994-1996 Automated monitoring of yellowfin tuna at Hawaiian FADs and relationship to water mass dynamics, Pelagic Fisheries Research Program, University of Hawaii, National Marine Fisheries Service (NMFS), \$202,000.
- 1993-1995 Development of sensors and algorithms for accurate position-determination by archival tag, Ocean Technology, NSF, \$176,541.
- 1992-1993 Symposium, "Biology of the White Shark," Bodega Bay Sea Urchin Assoc., California Academy of Sciences, Cousteau Society, Gulf of the Farallones National Marine Sanctuary, Marine Mammal Commission, National Audubon Society, ONR, Sea World, San Diego, \$15,300.
- 1990-1991 Long-term automated monitoring of pelagic fish assemblage at seamounts in the Gulf of California related to physical processes with satellite imagery, UC MEXUS, \$5,291.
- 1987-1990 Orientation/navigation mechanisms of pelagic sharks, Animal Behavior and Biological Oceanography, NSF, \$149,909.
- 1985-1986 Movement patterns and behavior of the white shark, *Carcharodon carcharias*, in the Point Reyes/Farallon National Marine Sanctuary, National Parks Service (NPS), \$35,780.
- 1985-1986 Behavioral ecology of the white shark in the Point Reyes/Farallon Marine Sanctuary, NGS, \$5,555.
- 1985-1987 Orientation/navigation mechanisms of pelagic sharks, Animal Behavior and Biological Oceanography, NSF, \$159,994.
- 1984-1985 Movement patterns and behavior of the white shark, *Carcharodon carcharias*, in the Point Reyes/Farallon National Marine Sanctuary, NPS, \$22,510.
- 1984-1985 Behavioral ecology of the white shark in the Point Reyes/Farallon Marine Sanctuary, NGS, \$8,413.
- 1982-1983 Behavior of the white shark, *Carcharodon carcharias*, and scalloped hammerhead, *Sphyrna lewini*, ONR, \$21,863.
- 1982-1983 Design and fabrication of microcomputer interface for decoding multisensor telemetry data and displaying it numerically and graphically in real time, Foundation for Ocean Research, \$15,859.

- 1981-1982 Funds for vessel rental for telemetric study of movement patterns of the scalloped hammerhead shark, *Sphyrna lewini*, in the Gulf of California, Ship Funding Committee, Scripps Institution of Oceanography, \$8,000.
- 1980-1981 Schooling and associated behaviors in the scalloped hammerhead, NGS, \$8,000.

CONSULTING

- 2007-2008 Study plan for the LTMS green sturgeon research, United States Army Corps of Engineers, \$15,711.
- 2006-2007 Connectivity of ocean migration between Galapagos, Mapelo, and Cocos Islands, Eastern Pacific Migratory Corridor Initiative, Conservation International, \$8,000.
- 1998-1999 Environmental Impact Statement (EIS), Effect of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) on marine mammals and fishes, Marine Acoustics Inc. (Subcontractor for Department of Defense), \$15,000.

SOCIETIES

American Association for the Advancement of Science.
 American Elasmobranch Society.
 American Fisheries Society
 American Society of Ichthyologists and Herpetologists.
 Association for the Study of Animal Behavior.
 Sigma Xi , Member.

EDITOR

- 1997-Pres. *Oecologia*, Off-board Editor.
 2005-2006 *Environmental Biology of Fishes*, Associate Editor.
 1995-2004. *American Scientist*, Consulting Editor, Animal Behavior & Marine Biology.

REVIEWER

African Journal of Marine Science (South Africa)
Animal Behavior (U.S.A.)
Australian Journal of Marine and Freshwater Research (Australia)
Canadian Journal of Zoology (Canada)
Ciencias Marinas (Mexico)
Copeia (U.S.A.)
Environmental Biology of Fishes (Canada)
Experimental Marine Biology and Ecology (U.K.)
Fisheries Bulletin (U.S.A.)
INTERFACE, The Royal Society (U.K.)
Journal of Fish Biology (England)
Journal of Fisheries Management (U.S.A.)

Marine Biology (Germany)
Marine Ecology Progress Series (U.S.A.)
Naturwissenschaften (Germany)
Northwestern Naturalist (U.S.A.)
Prentice Hall (U.S.A.)
Oecologia (U.S.A.)
Transactions of the American Fisheries Society (U.S.A.)
University of California, Press (U.S.A.)
University of Chicago, Press (U.S.A)

HONORS

- 2004 Who'sWho in America
- 2004 Writer's Guild
- 1998 Certificate of Excellence in recognition of "excellence in concept, design and manufacture" for Great White Sharks: The Biology of *Carcharodon carcharias*, Bookbuilders West Book Show.
- 1995 SNAP EXCEL Silver Award, Magazines: Feature Article, "The predatory behavior of the white shark," American Scientist.
- 1994 Presidential Nomination, American Elasmobranch Society.
- 1981 Scientific Achievement Award, Southern California Academy of Science.

LANGUAGES

German, Reading
Spanish, Fluent Reading and Speaking
Russian, Reading

INTERNET

- 2007-Pres. Central Valley Fish Tagging Consortium, Profile of APK (http://californiafishtracking.ucdavis.edu/org_davis_peter.html)
- 2005-Pres. Tagging of Pacific Pelagics (TOPP), Profile of APK (<http://www.toppcensus.org>).
- 2004-Pres. Biotelemetry Laboratory, Biographies of APK and graduate students with project descriptions (<http://wfcb.ucdavis.edu/www/faculty/Pete>).
- 1997-Pres. Dr. Hammerhead, NOVA/PBS web page, research featured and questions about shark biology answered (www.pbs.org/wgbh/nova/sharks/masters/hammerhead.html).

FILMS

- 2008 Hammerhead Highways, Geographic Explorer (U.S.A.), National Geographic Channel (U.S.A.) [Ongoing].
- 2008 Island of the White Shark, RTProductions (U.S.A.).
- 2007 Perfect Predators, Tigress Productions (U.K.), Discovery Channel (U.S.A.).
- 2006 Requins Sous Haute Surveillance, Cinémarine (France), Channel Three, Thallasa (France).
- 2004 Sharks in America, British Broadcasting Corporation (U.K.), British Television (U.K.).
- 2003 White Shark Behavior, British Broadcasting Corporation (U.K.), Discovery Channel (U.S.A.)
- 2002 White Sharks of South Africa, Discovery Films (U.S.A.), Discovery Channel (U.S.A.)
- 2002 Megasharks, Australian Broadcasting, Australian Television (Australia).
- 2001 Sharks at the Farallones, KGO-TV News, American Broadcasting, San Francisco.
- 1999 Tracking White Sharks at Año Nuevo Island, National Geographic Films (U.S.A.), National Geographic Channel (U.S.A.).
- 1999 Sharks of Cocos Islands, Howard Hall Productions (U.S.A.), NOVA (U.S.A.).
- 1998 Megahai, Beyond Productions Limited (Australia), German Television (Germany).
- 1998 Hammerheads: Nomads of the Sea, Thomas Lucas Productions (U.S.A.), Discovery Channel (U.S.A.).
- 1996 The Science of Shark Attacks, Turner Broadcasting Network (U.S.A.).
- 1995 The Red Triangle, Tom Horton Films (U.S.A.), Discovery Channel (U.S.A.).
- 1994 Sharks, Audubon Films (U.S.A.).
- 1993 The World of White Sharks, Osford Film Productions, Australia, Discovery Films.
- 1989 Hammerhead Science in Gulf of California, KTV, San Francisco (U.S.A.).
- 1988 World of Sharks, Public Broadcasting Service (U.S.A.), Turner Broadcasting Network (U.S.A.).
- 1983 Profiles of Ocean Pioneers, Public Broadcasting Service, U.S.A.

- 1982 Hammerheads of Sea of Cortez, Don Meir Productions (U.S.A.), Wild Kingdom (U.S.A.).

INTERVIEWS AND PUBLIC LECTURES

- 2003 The Secret Life of Sharks, interviewed by over 30 radio shows.
- 1999 Behavior and ecology of sharks, “Airtalk” with Larry Mantle, Public Radio, Los Angeles, California.
- 1999 White sharks preference for seals over humans, radio interview, “All Things Considered” with Linda Wertheimer, National Public Radio, Washington D.C.
- 1999 Tracking the white shark, television interview, John Fowler, Science Reporter, KTVU Oakland.
- 1998 Sharks: fact and fancy, radio interview, “These Days” with Dan Erwine, Public Radio, San Diego, California.
- 1998 Sharks: fact and fancy, public lecture, San Diego Natural History Museum, San Diego
- 1998 Tracking of white sharks at Año Nuevo Island, public lecture, Open House, Long Marine Laboratory, Santa Cruz.
- 1998 The behavior of sharks, radio interview, “Science for Schools,” Radio America, Washington D.C.

SYMPOSIUMS ORGANIZED

2005. The Green Sturgeon and Its Environment, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Holiday Inn Capital Plaza, Sacramento (with P.J. Allen, J.A. Israel, and J.T. Kelly).
2000. Revisiting the *Umwelt*: Environments of Animal Communication, University Club, UC Davis (with C.M. Greene, D.H. Owings, and L.A. Hart).
1992. Biology of the White Shark, Bodega Marine Laboratory, UC Davis (with D.G. Ainley).

SCIENTIFIC TALKS AND POSTERS (ABSTRACT PUBLISHED)

56. Klimley, P., R. Arauz, S. Bessudo, A. Hearn, H. Guzman, S. Henderson, J. Ketchum, G. Shillinger, and G. Soler. 2008. Movements of sharks at seamounts and island, biotic “hot spots”, relative to marine protected areas in the eastern Pacific Ocean Corridor. Talk, American Association for Advancement of Science, Boston.
55. Ketchum, J.T., A. Hearn, and A.P. Klimley. 2008. Shark movements and biological hotspots: implications for managing marine resources at the Galapagos Islands. Talk, Conservation Society, San Francisco Chapter, Oakland.

54. Klimley, A.P., Hamilton, S.A., Cech, J.J., Jones, G.J., Miranda, J.B., Cocherell, D.E., Chun, S., and L.C. Thompson. 2007. Responses of fish to pulsed-flow releases in the South Fork American River watershed. Talk, American River Water Conference, Sacramento State University, Sacramento.
53. Klimley, A.P. 2006. Acoustic arrays on seamounts and islands. Talk, Advanced Sampling Technology Workshop, Acoustic Tagging and Integrated Ocean Observing Systems, National Marine Fisheries Service, Santa Cruz.
52. Sandstrom, P.T., A.J. Ammann, L.L. Schlipp, R.B. MacFarlane, and A.P. Klimley. 2006. The range of detection of coded ultrasonic tags by automated monitors in the Sacramento-San Joaquin watershed. Poster, 4th Biennial CALFED Science Conference, Sacramento.
51. Klimley, A.P. and R.B. MacFarlane. 2006. Survival and migratory patterns of Central Valley juvenile salmonids. Poster, 4th Biennial CALFED Science Conference, Sacramento.
50. Hamilton, S.A., D.E. Cocherell, J.B. Miranda, G.J. Jones, J.J. Cech, P.S. Young, D.E. Conklin, J. O'Hagan, and A.P. Klimley. 2006. Trout behavior and responses to pulsed flows: investigations utilizing electrogymnogram telemetry. Poster, 4th Biennial CALFED Science Conference, Sacramento.
49. Heublein, J.C., J.T. Kelly, and A.P. Klimley. 2006. Spawning migration and habitat of green sturgeon, *Acipenser medirostris*, in the Sacramento River. Talk, 4th Biennial CALFED Science Conference, Sacramento.
48. Cocherell, D.E., S.A. Hamilton, and A.P. Klimley. 2006. Adult hardhead minnow and rainbow trout temperature preference in a large, annular apparatus. Talk, 4th Biennial CALFED Science Conference, Sacramento.
47. Richert, J.E., R. Cervantes-Duarte, R. Gonzalez-Armas, F. Galvan-Magaña. 2006. Spatio-temporal variability in the trophic ecology of large pelagic fishes of the southern Gulf of California, Talk, 55th Annual Tuna Conference, Lake Arrowhead.
46. Richert, J.E., R. Cervantes-Duarte, R. Gonzalez-Armas, F. Galvan-Magaña. 2006. Spatio-temporal variability in the trophic ecology of large pelagic fishes of the southern Gulf of California, Talk, American Society of Limnologists and Oceanographers, Halifax, Canada.
45. Jorgensen, S., S. Anderson, S. Van Sommeran, C. Fitz-Cope, B. Block, and P. Klimley. 2006. Ecological, physiological, and genetic studies of white sharks in the Gulf of the Farallones, Talk, Meeting of the American Society of Ichthyologists and Herpetologists, New Orleans.
44. Hoyos, M., C. Ribot, P. Blanco, P. Klimley, and M. Domeier. 2006. Preliminary studies of the genetics, isotope ratios, movements and behavior of white sharks at Guadalupe Island, Mexico. Talk, Meeting of the American Society of Ichthyologists, New Orleans, Louisiana.
43. Hamilton, S., S. Chun, J. Miranda, G. Jones, D. Cocherell, L.C. Thompson, A.P. Klimley. 2006. Trout behavioral response to pulsed flows: investigations utilizing radio and

electromyogram telemetry, Talk, VII International Congress of the Biology of Fish, St. John's, Newfoundland, Canada.

42. Thompson, L.C., S. Hamilton, G. Jones, J. Miranda, A.P. Klimley, and B. Hodge. 2006. Fish response to a one-way whitewater kayaking flow pulse release in Silver Creek, a tributary of the South Fork, American River. Talk, 40th Annual Meeting, California-Nevada Chapter, American Fisheries Society, San Luis Obispo, California.
41. Hamilton, S., S. Chun, J. Miranda, G. Jones, D. Cocherell, L.C. Thompson, and A.P. Klimley. 2006. Radio and electromyogram telemetry examining movement patterns, swimming speed and oxygen consumption of trout in response to pulsed flows in the American River. Talk, 40th Annual Meeting, California-Nevada Chapter, American Fisheries Society, San Luis Obispo, California.
40. Hamilton, S., S. Chun, J. Miranda, D. Cocherell, G. Jones, J. Graham, L.C. Thompson, and A.P. Klimley. 2005. Radio-telemetry studies assessing pulsed flow impacts on the behavior and distribution of fishes in the American River. Talk, First Pulsed Flow Program Workshop, Davis, California.
39. Hamilton, S. Chun, J. Miranda, D. Cocherell, G. Jones, J. Graham, L.C. Thompson, and A.P. Klimley 2005. Radio-telemetry studies assessing pulsed flow impacts on the behavior and distribution of fishes in the American River. Talk, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Sacramento, California.
38. Klimley, A.P., P.J. Allen, J.A. Israel, and J.T. Kelly. 2005. So where do we go from here? Scientific and management implications for conserving green sturgeon. Talk, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Sacramento, California.
37. Kelly, J.T. and C.E. Crocker. 2005. Movements of adult and sub-adult green sturgeon (*Acipenser medirostris*) in the San Francisco Bay Estuary, Talk, 39th Annual Meeting, California-Nevada Chapter, American Fisheries Society, Sacramento, California.
36. Jorgensen, S.J., M.R. O'Farrell, A.P. Klimley, S.G. Morgan, and L.W. Botsford. 2004. Site fidelity in a semi-pelagic rockfish (*Sebastes mystinus*): spillover or stay at home?, Talk, 85th Meeting, Western Society of Naturalists, Rohnert Park, California.
35. Richert, J.E., S.J. Jorgensen, A.P. Klimley, and A. Muhlia-Melo. 2004. Seamounts as hot spots of pelagic fish diversity in the Eastern Pacific Ocean, Poster, North Pacific Marine Science Organization, Honolulu.
34. Richert, J.E., S.J. Jorgensen, A.P. Klimley, and A. Muhlia-Melo. 2004. Investigating pelagic fish communities at seamounts in the southern Gulf of California: an integrative approach, Poster, Gulf of California Conference, Tucson.
33. Richert, J.E., S.J. Jorgensen, A.P. Klimley, and A. Muhlia-Melo. 2004. Ultrasonic tagging of pelagic fishes at seamounts in the Southern Gulf of California: an integrated approach, Poster, 55th Annual Tuna Conference, Lake Arrowhead.
32. Jeffres, C.A., A.P. Klimley, J.E. Merz, and J.J. Cech, Jr. 2004. Movement of Sacramento sucker (*Catostomus occidentalis*) and hitch (*Lavinia exilicauda*) during a spring, pulse flow

below Camanche Dam in the Mokelumne River, California, Talk, Annual Meeting, California-Nevada and Humboldt Chapters, American Fisheries Society.

31. Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2003. Movements of adult and sub-adult green sturgeon (*Acipenser medirostris*) in the San Francisco Estuary, Poster, 6th Biennial State of the Estuary Conference.
30. Richert, J., A. Muhlia-Melo, and A.P. Klimley. 2003. Examen del nicho ecológico de las comunidades de peces pelágicos asociados a montañas submarinas del Golfo de California, IX Congreso Asociación de Investigadores del Mar de Cortés.
29. Kelly, J.T and A.P. Klimley. 2002. Occurrence of white sharks at Point Reyes, Fifth Biennial Symposium of the Gulf of the Farallones.
28. Curtis, T.H., J.T. Kelly, K.L. Menard, R.K. Laroche, R.E. Jones, and A.P. Klimley. 2001. Scavenging of white sharks on humpback whale at Point Reyes, Fifth Biennial Symposium of the Gulf of the Farallones.
27. Klimley, A.P. and B.J. LeBoeuf. 2000. Tracking of white sharks at Año Nuevo Island, Biennial Workshop of the Gulf of the Farallones National Marine Sanctuary, San Francisco (invited speaker).
26. Klimley, A.P. 1999. The behavior and ecology of the white shark, *Carcharodon carcharias*, Congresso, Societa Italiana di Biologia Marina, Vibo Valentia, Italy (invited speaker).
25. Klimley, A.P. and C. Holloway. 1999. School fidelity and homing synchronicity of yellowfin tuna, *Thunnus albacares*, XXX Congresso, Societa Italiana di Biologia Marina, Vibo Valentia, Italy (invited speaker).
24. Klimley, A.P. and C. Holloway. 1998. Simultaneous tracking of five white sharks at Año Nuevo Island, Symposium in honor of Donald Nelson, American Society of Ichthyologists and Herpetologists (ASIH), University of Guelph, Canada (invited speaker).
23. Klimley, A.P. and C. Holloway. 1996. Benchmark tests of accuracy of two archival tags, workshop on Salmonid Biology, Ecology, and Oceanography, Seattle (invited speaker).
22. Klimley, A.P. and C. Holloway. 1996. Automated monitoring of yellowfin tunas at Hawaiian FADs, 47th Annual Tuna Conference, Lake Arrowhead, California.
21. Klimley, A.P. and C. Holloway 1995. Automated monitoring of yellowfin tuna at Hawaiian FADs, Workshop, Pelagic Fisheries Research Program, University of Hawaii, Hawaii.
20. Klimley, A.P. 1995. Approaches to improve geolocations from archival tags, Planning Workshop for Atlantic Bluefin Tuna Tagging Studies, Southeast Fisheries Center, Miami, Florida (invited speaker).

19. Klimley, A.P. 1994. Do white sharks (*Carcharodon carcharias*) select prey based upon high fat content?, American Society of Ichthyologists and Herpetologists (ASIH), University of Southern California, Los Angeles, California.
18. Klimley, A.P. and W. Mangan. 1994. Optimizing positional accuracy of archival tags with irradiance and magnetic sensors, 45th Annual Tuna Conference, Lake Arrowhead, California (invited speaker).
17. Klimley, A.P. and W. Mangan. 1994. "Listening" stations for retrieval of data from archival tags, 45th Annual Tuna Conference, Lake Arrowhead, California (invited speaker).
16. Klimley, A.P. 1993. Behavioral studies of white sharks and prey at the South Farallon Islands, Second Biennial Workshop on Research within the Gulf of the Farallones, San Francisco, California (invited speaker).
15. Klimley, A.P., S.D. Anderson, and P. Pyle 1993. Displays and intraspecific competition among white sharks, *Carcharodon carcharias*, during predatory attacks on pinnipeds, Symposium on the Biology of the White Shark, Bodega Marine Laboratory, UC Davis, Bodega Bay, California.
14. Klimley, A.P., S.D. Anderson, and P. Pyle. 1993. Behavior of white sharks and pinnipeds during predatory attacks: exsanguination versus bite and spit hypothesis, Symposium, on the Biology of the White Shark, Bodega Marine Laboratory, UC Davis, Bodega Bay, California.
13. Klimley, A.P., S.D. Anderson, P. Pyle, and R.P. Henderson. 1992. Spatio-temporal patterns of white shark (*Carcharodon carcharias*) predation at the South Farallon Islands, California, ASIH, University of Illinois, Urbana-Champaign, Illinois.
12. Klimley, A.P., I. Cabrera-Mancilla, and J.L. Castillo-Geniz. 1992. Descripcion de los movimientos horizontales y verticales del tiburón martillo (*Sphyrna lewini*) del sur del Golfo de California, Mexico, IX Symposium Internacional de Biología Marina, La Paz, Mexico.
11. Klimley, A.P., S.D. Anderson, P. Pyle, and R.P. Henderson. 1989. A description of predatory attacks by white sharks on pinnipeds, ASIH, California State University, San Francisco, California.
10. Klimley, A.P. 1988. Homing of a shark to a seamount and relationship to local geomagnetic features, Animal Behavior Society (ABS), University of Montana, Missoula and ASIH, University of Michigan, Ann Arbor, Michigan.
9. Klimley, A.P. and D.R. Nelson. 1983. Functional analysis of schooling in the scalloped hammerhead, *Sphyrna lewini*, Conference on Ethology and Behavioral Ecology of Fishes, University of Illinois, Normal, Illinois.
8. Klimley, A.P. 1983. Areal distribution of the white shark, *Carcharodon carcharias*, along the California coast, Southern California Academy of Science, California State University, Fullerton, California.

7. Klimley, A.P. and D.R. Nelson. 1982. Mass schooling of scalloped hammerhead sharks, *Sphyrna lewini*, in the Gulf of California, ABS, Colorado State University, Fort Collins, Colorado.
6. Klimley, A.P. 1980. Cardumenes de la cornuda, *Sphyrna lewini*, al Golfo de California, CIBCASIO, La Paz, Mexico.
5. Klimley, A.P. and S.T. Brown. 1982. Stereophotographic technique to determine individual size, spatial relationships, and size segregation within schools of the scalloped hammerhead, *Sphyrna lewini*, Southern California Academy of Science, California State University, Dominguez Hills, California.
4. Klimley, A.P. and S.T. Brown. 1982. Determinacion por medio de tecnicas estereofotografias del tamaño individual, relaciones especiales, y posible segregacion entre tamanos dentro de los cardumenes del tiburón cornuda, *Sphyrna lewini*, CIBCASIO, Ensenada, Mexico.
3. Klimley, A.P. 1982. Mass schooling of scalloped hammerhead sharks, *Sphyrna lewini*, in the Gulf of California, ABS, Colorado State University, Fort Collins, Colorado.
2. Klimley, A.P. 1980. Cardumenes de la cornuda, *Sphyrna lewini*, al Golfo de California, CIBCASIO, La Paz, Mexico.
1. Klimley, A.P. and A.A. Myrberg. 1977. Stimulus properties underlying withdrawal response in the lemon shark, *Negaprion brevirostris*, ASIH, University of Florida, Tallahassee, Florida.

SEMINARS

- 2003 The behavior of the white shark, Paul Szabo Memorial Lecture, Hackley Preparatory School, Tarrytown, New York.
- 2003 Hunting strategy of white sharks at seal colony, Marine Biology Division, Scripps Institution of Oceanography, San Diego, California.
- 2002 Predatory strategy of white sharks at a seal colony, John P. McGrath Seminar Series, Southampton College, New York.
- 2002 Behavior and ecology of the white shark, Tiburon Marine Center, San Francisco State University, California.
- 2001 Biophysics of hammerhead navigation, University of San Francisco, California.
- 2001 Dispelling the myths of sharks, Natural History Series, Mystic Aquarium, Connecticut.
- 2001 La importancia de conservacion de peces en Golfo de California, SEMERNAP, Marine Reserve Headquarters, Loreto, Mexico.

- 2000 Who is afraid of the white shark?, Behnke Memorial Lecture, Pacific Chapter, Undersea & Hyperbaric Medical Society, San Francisco, California.
- 2000 Hunting strategy of white sharks at seal colony, Boston University Marine Program (BUMP)/Woods Hole Oceanographic Institution (WHOI), Woods Hole, Massachusetts.
- 1999 Simultaneous tracking of white sharks at Año Nuevo Island, Long Marine Laboratory, UC Santa Cruz and UC Davis, California.
- 1998 School fidelity, homing synchronicity, and route traveling by pelagic fishes, Scripps Institution of Oceanography, University of California, San Diego.
- 1997 Homing synchronicity and school fidelity of yellowfin tunas, Southwest Fisheries Center, Tiburon, California.
- 1996 Electromagnetic landscape detection by scalloped hammerhead sharks, Center for Animal Behavior, UC Davis.
- 1996 Registro de presencia de atun aleta amarilla en los dispositivos de agregacion en Hawaii, utilizando sistemas de registro automatico continuo, Centro de Investigaciones Biologicas de Baja Noroeste (CIBNOR), La Paz, Mexico.
- 1995 The predatory behavior of the white shark, University of South Florida, University of Washington, Seattle, Washington, and UC Davis, California.
- 1994 The predatory behavior of the white shark, Washington State University, Pullman, Oregon.
- 1994 Development of sensors and algorithms for accurate position-determination by archival tag, Southwest Fisheries Center, Tiburon, California.
- 1993 The ecological determinants of movement patterns in the scalloped hammerhead shark, Southwest Fisheries Center, Hawaii.
- 1993 The predatory behavior of the white shark. Southwest Fisheries Center, Hawaii
- 1992 Autecology of the white shark along the western coast of North America, Oregon State University, Southwest Fisheries Center, Tiburon, California.
- 1991 Ecological determinants of movements and geomagnetic map-sense in the scalloped hammerhead shark, Scripps Institution of Oceanography, University of California, San Diego. California.
- 1990 The ecological determinants of movement patterns in the scalloped hammerhead shark, University of California, Santa Cruz, California.
- 1989 The ecological determinants of movement patterns in the scalloped hammerhead shark, University of California, Berkeley, California.

- 1988 Los determinantes ambientales por los movimientos de un tiburón pelágico, Departamento de la Pesca, Dirección de la Oceanografía, and Universidad Autónoma, D.F. Mexico.
- 1988 Autecology of the white shark along the western coast of North America, Oregon State University, Corvallis, Oregon.
- 1988 The ecological determinants of movement patterns in a pelagic shark, *Sphyrna lewini*, Oregon State University, Corvallis, Oregon.
- 1987 Sharks and divers, Naval Diving and Salvage Training Center, Panama City, Florida.
- 1987 Autecology of the white shark in California, California State University, Long Beach, California.
- 1987 Field studies of the white shark, *Carcharodon carcharias*, in the Gulf of Farallones National Marine Sanctuary, Point Reyes National Seashore Center, Point Reyes, California.
- 1986 The distribution and autecology of the white shark, *Carcharodon carcharias*, along the western coast of North America with particular reference to the Point Reyes-Farallon National Marine Sanctuary, Western Regional Headquarters, Point Reyes, California.
- 1986 The ecological determinants of movement patterns in the scalloped hammerhead shark, *Sphyrna lewini*, Bodega Marine Laboratory, Bodega Bay, California.
- 1985 The distribution and autecology of the white shark, *Carcharodon carcharias*, along the western coast of North America, Bodega Marine Laboratory, Bodega Bay, and Scripps Institution of Oceanography, La Jolla, California.
- 1985 A functional analysis of schooling in the scalloped hammerhead shark, *Sphyrna lewini*, Bodega Marine Laboratory, Bodega Bay, California.

BOOKS/SPECIAL ISSUES (IN PREP.)

- 1. Klimley, A.P. In prep. The Biology of the Sharks, Rays, and Chimaeras. University of California Press.

BOOKS/SPECIAL ISSUES (PUBLISHED)

- 4. Klimley, A.P., P. Allen, J. Israel, and J. Kelly (Eds). 2006. The green sturgeon, *Acipenser medirostris*, and Its Environment. Special Issue, *Environmental Biology of Fishes*, 79.
- 3. Klimley, A.P. 2003. The Secret Life of Sharks: A Leading Biologist Reveals the Mysteries of Shark Behavior. Simon and Schuster, New York, 292 pp.

2. Greene, C.M., D.H. Owings, L.A. Hart, and A.P. Klimley (Eds). 2002. Revisiting the *Umwelt*: Environments of Animal Communication. Special Issue, *Journal of Comparative Psychology*.
1. Klimley, A.P. and D.G. Ainley (Eds). 1996. Great White Sharks: The Biology of *Carcharodon carcharias*. Academic Press, San Diego, 528 pp.

ARTICLES (MANUSCRIPTS COMPLETED)

83. Cocherell, D.E., J.J. Cech, Jr., and A.P. Klimley. In prep. Temperature preferences of the hardhead minnow, *Mylopharodon conocephalus*, and rainbow trout, *Oncorhynchus mykiss*. *Transactions of the American Fisheries Society**
82. Chun, S., S.A. Hamilton, D.E. Cocherell, J.J. Cech, Jr., and A.P. Klimley. Experiments on the longitudinal displacement of rainbow trout, *Oncorhynchus mykiss*, and hardhead minnow, *Mylopharodon conocephalus*. *Transactions of the American Fisheries Society**
81. Chun, S., S.A. Hamilton, D.E. Cocherell, J.J. Cech, Jr., and A.P. Klimley. Experiments on the lateral displacement of rainbow trout *Oncorhynchus mykiss* and hardhead minnow *Mylopharodon conocephalus*. *Transactions of the American Fisheries Society**
80. Hamilton, S.A., S. Chun, G. Jones, J. Miranda, and L. Thompson. In prep. Activity of brown trout monitored using electromyogram- detecting transmitters during pulsed flows in South Fork of American River. *Transactions of the American Fisheries Society**
79. Hamilton, S.A., G.J. Jones, J.B. Miranda, D.E. Cocherell, J.J. Cech, L.C. Thompson, and A.P. Klimley. In prep. Distribution of juvenile and adult rainbow trout, *Oncorhynchus mykiss*, during pulsed flows in the South Fork American River, California. *Transactions of the American Fisheries Society**
78. Thompson, L.C., S. A. Hamilton, S. Chun, A.P. Klimley, and J.J. Cech. In prep. Longitudinal movement of fish in response to a single-day flow pulse. *Transactions of the American Fisheries Society**
77. Kelly, J.T., S.E. Lankford, J.J. Cech Jr. & A. P.Klimley. In prep. The energetic costs of swimming using flow-vector kinesis in green sturgeon (*Acipenser medirostris*). *Science*.
76. Kelly, J.T. and A.P. Klimley. Flow vector kinesis by green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California. *Marine Biology*.
75. Jorgensen, S.J., J.E. Richert., and A.P. Klimley. In prep. Seasonal assemblages of fishes at seamount in the Gulf of California. *Ecology*.

*Will be submitted together as tandem publications during 2007 in *Transactions of the American Fisheries Society*.

SCIENTIFIC ARTICLES (SUBMITTED)

74. Mazur, R.A. and A.P. Klimley. Submitted. Telemetric study of variation in black bear home ranges in relation to preferred foods in Sequoia National Park, California. *Ecology*.
73. Heublein, J., J.T. Kelly, C.E. Crocker, and A.P. Klimley. Submitted. Migration of green sturgeon in Sacramento River. *Transactions of the American Society of Fisheries*.
72. Richert¹, J. E., S. J. Jorgensen, J.T. Ketchum, L. Mohajerani, and A.P. Klimley. Submitted. The importance of seamounts to pelagic fishes and fisheries off the southern Baja Peninsula. *Fisheries Management and Ecology*.
71. Jorgensen, S.J., A.P. Klimley, and A. Muhlia-Melo. Submitted. Diving of scalloped in anoxic zone in Gulf of California. *Environmental Biology of Fishes*.
70. Ketchum, J.T. and F. Galván-Magaña. Submitted. Distribution, segregation, environmental preferences, and habitat use of whale sharks (*Rhincodon typus*) in the southwestern Gulf of California. *Marine Ecology Progress Series*.
69. Campos, B., M. Fish, G. Jones, R. Rily, A.J. Allen, A.P. Klimley, and J.J. Cech. Submitted. Movement of brown smoothhound sharks in Tomales Bay, California: effects diel and tidal cycles. *Environmental Biology of Fishes*.

SCIENTIFIC ARTICLES (IN PRESS)

68. Lindley, S.T., M.L. Moser, D.F. Erickson, M. Belchik, D.W. Welch, E. Rechiski, J. Heublein, J.T. Kelly, and A.P. Klimley. 2007. Marine migration of North American green sturgeon. *Transactions of the American Society of Fisheries*.
67. Klimley, A.P. 2007. Electric field production and detection in animals. *The Encyclopedia of Applied Animal Behaviour and Welfare*, University of Lincoln, Riseholme Park, United Kingdom.

SCIENTIFIC ARTICLES (PUBLISHED)

66. Klimley, P. 2007. Colourplate section. *Environmental Biology of Fishes*, 79: 423-425.
65. Klimley, A.P., P. J. Allen, J. A. Israel and J.T. Kelly. 2007. Green Sturgeon and its Environment: Past, Present, and Future. *Environmental Biology of Fishes*, 79: 415-421.
64. Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Estuary, California. *Environmental Biology of Fishes*, 29: 281-195.
63. Klimley, A.P., P. J. Allen, J. A. Israel and J.T. Kelly. 2007. Green Sturgeon and its Environment: Introduction. *Environmental Biology of Fishes*, 79: 187-190.
62. Qayum, H.A., A.P. Klimley, J.E. Richert, and R. Newton. 2006. Broad-band versus narrow-band irradiance for estimating latitude by archival tags. *Marine Biology*, 151: 467-481.

61. Klimley, A.P. and T.C. Curtis. 2006. Attack versus ecotourism: negative and positive interactions. Pp. 33-44 in Timm, R.M. and J.M. O'Brien (Eds.), Proceedings, Twenty-Second Vertebrate Pest Conference. University of California, Davis.
60. Jorgensen, S.J., D.M. Kaplan, A.P. Klimley, S. G. Morgan, M.R Ferrell, and L.W. Botsford. 2006. Limited movement of blue rockfish (*Sebastes mystinus*): internal structure of the home range. *Marine Biology Progress Series*, 327: 157-170.
59. Jeffres, C.A., A.P. Klimley, J.E. Merz, and J.J. Cech, Jr. 2006. Movement of Sacramento sucker (*Catostomus occidentalis*) and hitch (*Lavinia exilicauda*) during a spring release of water from Camanche Dam in the Mokelumne River, California. *Environmental Biology of Fishes*, 75: 365-373.
58. Curtis, T.H., J.T. Kelly, K.L. Menard, R.K. Laroche, R.E. Jones, and A.P. Klimley. 2006. Observations of the behavior white sharks scavenging at a whale carcass at Point Reyes, California. *Bulletin, California Fish and Game*, 92:113-124.
57. Klimley, A.P., J.T. Kelly, and R.L. Kihlslinger. 2005. Directional and non-directional movements of bat rays, *Myliobatis californica*, in Tomales Bay, California. *Environmental Biology of Fishes*, 74:79-88.
56. Klimley, A.P., J.E. Richert, and S.J. Jorgensen. 2005. The home of blue water fish. *American Scientist*, 93:42-49.
55. Kelly, J.T and A.P. Klimley. 2003. The occurrence of the white shark, *Carcharodon carcharias*, at Point Reyes Headlands, California. *Bulletin of California Fish and Game*, 89: 187-196.
54. Muhlia-Melo, A., P. Klimley, R. González-Armas, S. Jorgensen, A. Trasviña-Castro, J. Rodriguez-Romero, and A. Amador-Buenrostro. 2003. Study of the pelagic assemblages of the Espiritu Santo seamount during El Niño 97-98 conditions. *Geophysica Internacional*, 42: 473-481.
53. Klimley, A.P., S.J. Jorgensen, A. Muhlia-Melo, and S.C. Beavers. 2003. Movements of yellowfin tuna (*Thunnus albacares*) to and from Espiritu Santo Seamount in Gulf of California. *Fisheries Bulletin*, 101: 684-692.
52. Greene, C.M., D.H. Owings, L.A. Hart, A.P. Klimley. 2002. Revisiting the *umwelt*: environments of animal communication. *Journal of Comparative Psychology*, 116: 115.
51. Kihlslinger, R.L. and A.P. Klimley. 2002. Species identity and the temporal characteristics of fish acoustic signals. *Journal of Comparative Psychology*, 116: 210-214.
50. Klimley, A.P., S. C. Beavers, T.H. Curtis, and S.J. Jorgensen. 2002. Movements and swimming behavior of three species of sharks in La Jolla Canyon, California. *Environmental Biology of Fishes*, 63: 117-135.
49. Klimley, A.P., B.J. Le Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, S. Van Sommeran, and J.T. Kelly. 2001. The hunting strategy of white sharks at a pinniped colony. *Marine Biology*. 13: 617-636.

48. Klimley, A.P., B.J. Le Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, and S. Van Sommeran. 2001. Radio-acoustic positioning: a tool for studying site-specific behavior of the white shark and large marine vertebrates. *Marine Biology*, 138:429-446.
47. Klimley, A.P. 1999. Sharks beware. *American Scientist*, 87: 488-491.
46. Klimley, A.P. and C. Holloway. 1999. Homing synchronicity and schooling fidelity by yellowfin tuna. *Marine Biology*, 133: 307-317.
45. Klimley, A.P. and S.C. Beavers. 1998. Playback of ATOC-type signal to bony fishes to evaluate phonotaxis. *Journal of Acoustic Society of America*, 104:2506-2510.
44. Klimley, A.P., F. Voegeli, S.C. Beavers, and B.J. Le Boeuf. 1998. Automated listening stations for tagged marine fishes. *Marine Technology Journal*, 32: 94-101.
43. Klimley, A.P. and C. Holloway. 1997. Benchmark tests of accuracy of two archival tags. P. 34 in Boehlert, G.W. (Ed.), *Application of Acoustic and Archival Tags to Assess Estuarine, Nearshore, and Offshore Habitat Utilization and Movement by Salmonids*. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-236, 62 pp.
42. Klimley, A.P. 1996. Dancing with sharks. *Natural History Magazine*, 105:54-55.
41. Sillman, A.J., G.A. Letsinger, S. Patel, E.R. Loew, and A.P. Klimley. 1996. Visual pigments and photoreceptors in two species of shark, *Triakis semifasciata* and *Mustelus henlei*. *Journal of Experimental Zoology*, 276:1-10.
40. Klimley, A.P. and D.G. Ainley. 1996. White shark research in the past: a perspective. Pp. 3-4 in Klimley, A.P. & D.G. Ainley (Eds.), IBID.
39. Klimley, A.P. and S.D. Anderson. 1996. Residency patterns of white sharks at the South Farallon Islands, California. Pp. 365-373 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
38. Klimley, A.P., P. Pyle, and S.D. Anderson. 1996. The behavior of white shark and prey during predatory attacks. Pp. 175-191 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
37. Klimley, A.P., P. Pyle, and S.D. Anderson, 1996. Is the Tail Slap an agonistic display among white sharks? Pp. 241-255 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
36. Anderson, S.D., A. P. Klimley, P. Pyle, and R.H. Henderson. 1996. Tidal height and white shark predation at the South Farallon Islands. Pp. 275-279 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
35. Goldman, K.J., S. D. Anderson, J.E. McCosker, and A.P. Klimley. 1996. Temperature, swimming depth, and diel movements of a white shark at the South Farallon Islands, Central California, with comments on thermal physiology. Pp. 111-120 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.

34. Mollet, H., G.M. Cailliet, A.P. Klimley, D.A. Ebert, A.T. Testi, and L.J.V. Compagno. 1996. A review of length validation methods for large white sharks. Pp. 91-108 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
33. Pyle, P., S.D. Anderson, A.P. Klimley, and R.P. Henderson. 1996. Environmental factors affecting the occurrence and behavior of white sharks at the South Farallon Islands, California. Pp. 281-291 in Klimley, A.P. and D.G. Ainley (Eds.), IBID.
32. Klimley, A.P. 1995. Hammerhead city. *Natural History*, 104:32-39.
31. Klimley, A.P., E.D. Prince, R.W. Brill, and K. Holland. 1994. Archival tags 1994: present and future. *NOAA Technical Memorandum*, NMFS-SEFSC-357, 30 pp.
30. Klimley, A.P. 1994. The predatory behavior of the white shark. *American Scientist*, 82:122-133 (won Silver Excel Award for best feature article of year).
29. Klimley, A.P. 1993. Highly directional swimming by scalloped hammerhead sharks, *Sphyrna lewini*, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. *Marine Biology*, 117:1-22.
28. Klimley, A.P., I. Cabrera-Mancilla, and J.L. Castillo-Geniz. 1993. Descripcion de los movimientos horizontales y verticales del tiburón martillo *Sphyrna lewini*, del sur de Golf de California, Mexico. *Ciencias Marinas*, 19:95-115.
27. Klimley, A.P., S.D. Anderson, P. Pyle, and R.P. Henderson. 1992. Spatio-temporal patterns of white shark (*Carcharodon carcharias*) predation at the South Farallon Islands, California. *Copeia*, 1992:680-690.
26. Galvan-Magaña F., H. Nienhuis, and A.P. Klimley. 1989. Seasonal abundance and feeding habits of sharks of the Lower Gulf of California. *California Fish and Game*, 75:74-84.
25. Klimley, A.P. and S.B. Butler. 1988. Immigration and emigration of a pelagic fish assemblage to seamounts in the Gulf of California related to water mass movements using satellite imagery. *Marine Ecology Progress Series*, 49:11-20.
24. Klimley, A.P., S.B. Butler, D.R. Nelson, and A.T. Stull, 1988. Diel movements of scalloped hammerhead sharks (*Sphyrna lewini* Griffith and Smith) to and from a seamount in the Gulf of California. *Journal of Fish Biology*, 33:751-761.
23. Klimley, A.P. 1987. Field studies of the white shark, *Carcharodon carcharias*, in the Gulf of Farallones National Marine Sanctuary. Pp. 33-36 in Croom, M.M. (Ed.), Current Research Topics in the Marine Environment. Gulf of the Farallones National Marine Sanctuary, San Francisco.
22. Cigas, J. and A.P. Klimley. 1987. A microcomputer interface for decoding telemetry data and displaying them numerically and graphically in real time. *Behavioral Research Methods, Instruments, and Computers*, 19:19-25.

21. Klimley, A.P. 1987. The determinants of sexual segregation in the scalloped hammerhead, *Sphyrna lewini*. *Environmental Biology of Fishes*, 18:27-40.
20. Klimley, A.P. 1985. Schooling in the large predator, *Sphyrna lewini*, a species with low risk of predation: a non-egalitarian state. *Zeitschrift für Tierpsychologie (=Ethology)*, 70:297-319.
19. Klimley, A.P. and D.R. Nelson. 1985. Functional analysis of schooling in the scalloped hammerhead shark (*Sphyrna lewini*). *Research Reports*, National Geographic Society, 21:227-229.
18. Klimley, A.P. 1985. The areal distribution and autoecology of the white shark, *Carcharodon carcharias*, off the west coast of North America. *Southern California Academy of Sciences*, Memoirs, 9:15-40.
17. Klimley, A.P. and D.R. Nelson. 1984. Diel movement patterns of the scalloped hammerhead shark (*Sphyrna lewini*) in relation to El Bajo Espiritu Santo: a refuting central-position social system. *Behavioral Ecology and Sociobiology*, 15:45-54.
16. Klimley, A.P. and S.T. Brown. 1983. Stereophotography for the field biologist: measurement of lengths and three-dimensional positions of free-swimming sharks. *Marine Biology*, 74:175-185.
15. Klimley, A.P. and S.T. Brown. 1983. A stereophotographic technique for the determination of lengths of free-swimming sharks. *CIBCASIO Transactions*, 11:110-137.
14. Klimley, A.P. 1982. Social organization of schools of scalloped hammerhead shark, *Sphyrna lewini* (Griffith and Smith), in the Gulf of California. Dissertation, University of California, San Diego, 341 pp.
13. Klimley, A.P. 1981. Grouping behavior in the scalloped hammerhead. *Oceanus*, 24:65-71.
12. Klimley, A.P. and D.R. Nelson. 1981. Schooling of scalloped hammerhead, *Sphyrna lewini*, in the Gulf of California. *Fishery Bulletin*, 79:356-360.
11. Klimley, A.P. 1980. Observations of courtship and copulation in the nurse shark, *Ginglymostoma cirratum*. *Copeia*, 1980:878-882.
10. Klimley, A.P. and A.A. Myrberg, Jr. 1979. Acoustic stimuli underlying withdrawal from a sound source by adult lemon sharks, *Negaprion brevirostris* (Poey). *Bulletin of Marine Science*, 29:447-458.
9. Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1978. Rapid withdrawal from a sound source by open ocean sharks. *Journal of the Acoustical Society of America*, 64:1289-1297.
8. Klimley, A.P. 1978. Nurses at home and school. *Marine Aquarist*, 8:5-13.
7. Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1976. Attraction of free-ranging sharks by low frequency sound, with comments on its biological significance. Pp. 205-239

in A. Schuijf and A.D. Hawkins (Eds.), Sound Reception in Fishes. Elsevier Press, New York.

6. Klimley, A.P. 1976. Analysis of acoustic stimulus properties underlying withdrawal in the lemon shark, *Negaprion brevirostris* (Poey). Thesis, Rosenstiel School of Marine and Atmospheric Science, 80 pp.
5. Klimley, A.P. 1976. The white shark: a matter of size. *Sea Frontiers*, 22:2-8.
4. Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1975. Rapid withdrawal from a sound source by sharks under open ocean and captive conditions. *Technical Report*, University of Miami, 24 pp.
3. Myrberg, Jr., A.A., C.R. Gordon, and A.P. Klimley. 1975. Attraction of free-ranging sharks by acoustic signals in near-subsonic range. *Technical Report*, University of Miami, 32 pp.
2. Klimley, A.P. 1975. A new look at shark attack. *Triton*, 1975:11-15.
1. Klimley, A.P. 1974. An inquiry into the causes of shark attacks. *Sea Frontiers*, 20:66-75.

REPORTS

3. Klimley, A.P., J.J. Cech, Jr., S.I. Doroshov, B.P. May, and I. Werner. 2006. Biological assessment of green sturgeon in the Sacramento/San Joaquin watershed, Phase 5. CALFED Ecosystem Restoration Progra, Contract ERP-02D-P57,
- 2*. Klimley, A.P., L.C. Thompson, and J.J. Cech, Jr. 2006. Experimental and field studies to assess pulsed water flow impacts on the behavior and distribution of fishes in the South Fork of the American River. Public Interest Energy Research Program, California Energy Commission.
1. Klimley, A.P. 2005. Life history model for the green sturgeon, *Acipenser medirostris*. Delta Regional Ecosystem Restoration Implementation Plan, California Bay-Delta Authority.

CRUISES (CHIEF SCIENTIST)

- 2000 Automated monitoring of white sharks and seals, 24 days, Central California, R/V Robert Gordon Sproul, Scripps Institution of Oceanography, University of California, San Diego.
- 1999 Studies of pelagic fish assemblage at seamounts and islands, 16 days, Gulf of California, Mexico, R/V Robert Gordon Sproul, Scripps Institution of Oceanography, University of California, San Diego.

- 1999 Studies of pelagic fish assemblage at seamounts and islands, 10 days, Gulf of California, Mexico, R/V BIP, Centro de Investigaciones Biologicas de Baja California del Norte (CIBNOR).
- 1989 Telemetry tracking of sharks, 28 days, Gulf of California, Mexico, scientific party of 10 United States and 8 Mexican scientists, R/V Robert Gordon Sproul, Scripps Institution of Oceanography, University of California, San Diego.
- 1988 Geomagnetic, bathymetric surveys, and tracking of sharks, 33 days, Gulf of California, Mexico, 11 United States and 10 Mexican scientists, R/V Robert Gordon Sproul, Scripps Institution of Oceanography, University of California, San Diego.
- 1986 Record attendance of sharks at seamount with coded tags and moored automated data loggers, 34 day, 10 United States and 9 Mexican scientists, R/V Robert Gordon Sproul, Scripps Institution of Oceanography, University of California, San Diego.
- 1985 Detect visitation of sharks to seamount with individually coded tags and moored automated data loggers, 20 days, Gulf of California, Mexico, 4 United States and 3 Mexican scientists, Private charter, La Paz.
- 1983 Telemetry tracking of white sharks, 4 X 4-day cruises, Gulf of the Farallones, 6 scientist per cruise, R/V Susan K, Bodega Marine Laboratory, UC Davis.
- 1982 Studies of social organization of sharks, 3 X 10-day cruises, 4 United States and 6 Mexican scientists per cruise, R/V Don Juan Batiz, Centro de Ciencias Interdisciplinarios de Ciencias Marinas, La Paz.
- 1981 Telemetry tracking of sharks, 10 days, 10 United States and 10 Mexican scientists, Don Jose Abaroa, Private charter, La Paz.
- 1980 Studies of social organization of sharks, 3 X 10-day cruises, 4 United States and 6 Mexican scientists per cruise, R/V Don Juan Batiz, Centro de Ciencias Interdisciplinarios de Ciencias Marinas, La Paz.

TEACHING (UNDERGRADUATE)

TEACHING (UNDERGRADUATE)

COURSES

- Annually Guest lecturer, "Techniques for Marine Vertebrates", Field Methods in Ecology (WFC 100), Wildlife, Fish, and Conservation Biology (WFCB), Instructors, D. Anderson, D. Kelt, and D. Van Vuren.
- Annually. Guest lecturer, "Electroreception in Fishes", Physiology of Fishes (WFC 121), WFCB, UC Davis, Instructor, J. Cech.
- Annually Guest lecturer, "Conservation of Sharks," Wildlife Ecology and Conservation (WFC 10), Instructors, D. Kelt and P. Moyle.

- Annually. Guest lecturer, “Physiological Telemetry”, Physiological Ecology (ECL 203), Physiology Graduate Group, UC Davis, Instructors, J. Cech. and S. Doroshov,.
- Spring 2000¹ Instructor, Methods in Marine Vertebrate Biology (WFC 195) Wildlife, Fish, and Conservation Biology.
- Spring 2000¹ Instructor, Methods in Marine Vertebrate Biology/Advanced Laboratory Topics (WFC198), Wildlife, Fish, and Conservation Biology.
- Fall 1999 Instructor, Marine Conservation Biology (WFC 190), WFCB, UC Davis.
- Spring 1999 Guest lecturer, “Ecology of Sharks”, Population Biology and Ecology (BIS 122), Bodega Marine Laboratory, UC Davis, Instructor: Strong.
- Fall 1998 Guest lecturer, “Sharks of California”, Marine Biology Quarter (MBQ), UC Los Angeles (at Bodega Marine Laboratory), Instructor, Buth.
- Spring 1998. Guest lecturer, “Animal Migration and Navigation”, Introduction to Animal Behavior (NPB 102), Department of Neurobiology, Physiology, and Behavior, UC Davis, Instructors: Clayton and Nevitt.
- Winter 1985. Guest lecturer, “Social Organization of Animal Societies”, Animal Behavior (BIO 351), Department of Biology, California State University, Long Beach, Instructor, Nelson.

ADVISING

RESEARCH FELLOWS (REU, NSF)

- Summer 1998 Kelly Cantara, Southampton University, New York.
- Summer 1998 Salvador Jorgensen, State University of California, Sonoma, California.
- Summer 1998 David Melrose, State University of California, Sonoma, California.

RESEARCH INTERNS

- Spring 2005 Terry Fei Fan Ng, Special Study for Advanced Undergraduates (WFC 199), University of California, Davis.
- Spring 2005 Emily Berryhill, Special Study for Advanced Undergraduates (WFC 199), University of California, Davis.
- Spring 2004 Atsumi Ngui, Special Study for Advanced Undergraduates (WFC 199), University of California, Davis.

¹ Student evaluations submitted for course.

- Spring 2003 Emily Dickson, Special Study for Advanced Undergraduates (WFC 199), University of California, Davis.
- Summer 1999 Tobey Curtis, Undergraduate Research Thesis, Southampton University, New York.
- Spring 1999 John Richert, Undergraduate Research Thesis, Southampton University, New York.
- Spring 1998 Kelly Cantara, Undergraduate Research Thesis, Southampton University, New York.
- Spring 1996 Nathan Kochly, Senior Research Thesis, UC Santa Cruz, California.
- Summer 1995 George Letsinger, Special Study for Advanced Undergraduates (NPB 199), UC Davis, Co-supervisor, Sillman.
- Summer 1995 Sean Patel, Special Study for Advanced Undergraduates (NPB 199), UC Davis, Co-supervisor, Sillman,.
- Spring 1995 Elizabeth Anthony, Senior Research Thesis, UC Santa Cruz, California.

TEACHING (GRADUATE)

GROUP MEMBERSHIPS

- 2007-Pres. Membership, Graduate Group in Geography, UC. Davis
- 1999-Pres. Membership, Graduate Group in Ecology, UC Davis.
- 1998-Pres. Membership, Animal Behavior Graduate Group, UC Davis.

COURSES

- Winter 2003 Instructor, Biotelemetry in Ecology (EEG 290), Ecology Graduate Group, UC Davis.
- Winter 2000 Instructor, Communication: The Animal in the Context of the Environment (ANB 230), Animal Behavior Graduate Group, UC Davis, Co-instructors, Hart, Marler, and Owings.
- Fall 1999 Instructor, Management and Fisheries Ecology (ECL 290), Co-instructor, Dewees.
- Winter 1998. Instructor, "Behavioral and Sensory Adaptations to the Marine Environment", Seminar on Animal Behavior (ANB 290), Animal Behavior Graduate Group, UC Davis.

- Fall 1998. Guest lecturer, “Ethological Analysis”, Methods and Grant Writing (ANB 201), Department of Neurobiology, Physiology, and Behavior, UC Davis, Instructor: Nevitt.
- Spring 1983 Guest lecturer, “Elasmobranchs”, Ichthyology (S 294A), Scripps Institution of Oceanography, UC San Diego, Instructor, Rosenblatt.
- Winter 1983 Instructor, Quantitative Methods of Ethological Analysis (S 296), Scripps Institution of Oceanography, UC San Diego, Co-instructor, Heiligenberg.

STUDENTS (MAJOR PROFESSOR)

- 2007-Pres. Phillip Sandstrom, Ph.D., Ecology Graduate Group, UC Davis.
- 2005-Pres. James Ketchum, Ph.D., Ecology Graduate Group, UC Davis, CONACYT Predoctoral Fellow.
- 2003-Pres. Emma Grigg, Ph.D., Ecology Graduate Group, UC Davis.
- 2001-2007. John Richert, Ph.D., Ecology Graduate Group, UC Davis, NSF Predoctoral Fellow.
- 2001-2007. John Kelly, Ph.D., Animal Behavior Graduate Group, UC Davis, Postdoctoral Fellow, Conte Anadromous Fish Research Center, University of Massachusetts.

STUDENTS (COMMITTEE MEMBER)

- 2007-Pres. Phillip Sandstrom, Ph.D., Integrative Ecology, Ecology Graduate Group.
- 2007-Pres. Kim Sora, Ph.D., Department of Geology, UC Santa Cruz.
- 2006-Pres. Danielle Brown, Ph.D., Animal Behavior Graduate Group, UC Davis.
- 2007-Pres. Taylor Chapple, Ph.D., Marine Ecology, Ecology Graduate Group, UC Davis.
- 2006-Pres. Holly Nance, Ph.D., Department of Biology, Clemson University.
- 2005-Pres Sean Hanser, Marine Ecology, Ecology Graduate Group
- 2005-2007. Rachel Mazur, Ph.D., Conservation Ecology, Ecology Graduate Group, UC Davis, United States Forestry Service.
- 2005-Pres. Katherine McHugh, Animal Behavior Graduate Group, UC Davis, NSF Predoctoral Fellow, Committee Member.
- 2003-Pres. Mauricio Hoyos-Padilla, Ph.D., Centro de Investigaciones Interdisciplinarias de Ciencias Marinas, CICIMAR, Co-supervisor with F. Galvan-Magaña

- 2001-2006 Salvador Jorgensen, Ph.D., Marine Ecology, Ecology Graduate Group, UC Davis, Postdoctoral Fellow, Hopkins Marine Laboratory, Stanford University.
- 1996-2001. Jesus Rodriguez-Romero, Ph.D., Departamento de Ciencias Marinas, Centro de Investigaciones Biologicas, Norte de California (CIBNOR), Mexico, Co-supervisor with A. Muhlia-Melo.
- 1995-2000 Rogelio Gonzales-Armas, Ph.D., Departamento de Ciencias Marinas, CIBNOR, Mexico, Co-supervisor with A. Muhlia-Melo.
- 1995-2000 Agustin Hernandez-Herrera, Ph.D., Departamento de Ciencias Marinas, CIBNOR, Mexico , Co-supervisor with Muhlia-Melo.
- 1996-1998 Joseph Reid, M.Sci., Ecology Graduate Group, UC Davis, Co-supervisor with J. Cech.
- 1995-1997 Larry Bucholz, M.Sc., Electrical Engineering Graduate Group, UC Davis, Co-supervisor with R. Spencer.
- 1985-1988 Steven Butler, M.Sci., Scripps Institution of Oceanography, UC San Diego, Co-supervisor with R. Rosenblatt.

STUDENTS (QUALIFYING EXAM MEMBER)

- 2006 Tim Mussen, Ph.D., Conservation Ecology, Ecology Graduate Group, UC Davis, Subject: Behavioral Ecology.
- 2005 Rachel Mazur, Ph.D., Conservation Ecology, Ecology Graduate Group, UC Davis, Subject: Quantitative Methods.

Transcript Data**STUDENT INFORMATION****Birth Date:** Sep 10, 1981**Student Type:** Continuing**Curriculum Information****Current Program****College:** Graduate
Studies**Major:** Ecology

***Transcript type:STU is NOT Official ***

DEGREES AWARDED**Sought:** Doctor of
Philosophy**Degree
Date:****Curriculum Information****Primary Degree****Major:** Ecology

| | Passed | Completed | Attempted | Grade Points | GPA |
|---------------------|--------|-----------|-----------|-----------------|------|
| Institution: | 16.000 | 30.000 | 16.000 | 62.50 | 3.90 |

INSTITUTION CREDIT -Top-**Fall Quarter 2007****College:** Graduate Studies**Major:** Ecology**Student Type:** New**Academic
Standing:** Good Standing

| Subject | Course | Title | Grade | Units | Grade Points | Start and End Dates | R |
|---------|--------|----------------------------|-------|-------|-----------------|------------------------------|---|
| ECL | 200A | Principles of Ecology | A- | 5.000 | 18.50 | | |
| ECL | 231 | Math Method Pop Biol | A | 3.000 | 12.00 | | |
| ECL | 290 | Seminar In Ecology | S | 1.000 | 0.00 | | |
| ECL | 296 | Topics In Ecol and Evol | S | 1.000 | 0.00 | | |

| | | | | | | | | |
|--|---------------|-------------------------|------------------|------------------|---------------------|----------------------------|------------|--|
| WFC | 299 | Research | S | 4.000 | 0.00 | | | |
| Term Totals (Graduate Level - Qtr.) | | | | | | | | |
| | | | Passed | Completed | Attempted | Grade Points | GPA | |
| Current Term: | | | 8.000 | 14.000 | 8.000 | 30.50 | 3.81 | |
| Cumulative: | | | 8.000 | 14.000 | 8.000 | 30.50 | 3.81 | |
| Unofficial Transcript | | | | | | | | |
| Winter Quarter 2008 | | | | | | | | |
| College: | | Graduate Studies | | | | | | |
| Major: | | Ecology | | | | | | |
| Student Type: | | Continuing | | | | | | |
| Academic Standing: | | Good Standing | | | | | | |
| Subject | Course | Title | Grade | Units | Grade Points | Start and End Dates | R | |
| ECL | 200B | Principles of Ecology | A | 5.000 | 20.00 | | | |
| ECL | 232 | Theoretical Ecology | A | 3.000 | 12.00 | | | |
| ECL | 290 | Seminar In Ecology | S | 1.000 | 0.00 | | | |
| ECL | 296 | Topics In Ecol and Evol | S | 1.000 | 0.00 | | | |
| GEL | 292 | River Forum | S | 1.000 | 0.00 | | | |
| WFC | 299 | Research | S | 5.000 | 0.00 | | | |
| Term Totals (Graduate Level - Qtr.) | | | | | | | | |
| | | | Passed | Completed | Attempted | Grade Points | GPA | |
| Current Term: | | | 8.000 | 16.000 | 8.000 | 32.00 | 4.00 | |
| Cumulative: | | | 16.000 | 30.000 | 16.000 | 62.50 | 3.90 | |
| Unofficial Transcript | | | | | | | | |
| TRANSCRIPT TOTALS (GRADUATE LEVEL - QTR.) -Top- | | | | | | | | |
| | | Passed | Completed | Attempted | Grade Points | GPA | | |
| Total UC Davis: | | 16.000 | 30.000 | 16.000 | 62.50 | 3.90 | | |
| Total UC: | | 16.000 | 30.000 | 16.000 | 62.50 | 3.90 | | |
| Total Transfer: | | 0.000 | 0.000 | | | | | |
| Overall: | | 16.000 | 30.000 | | | | | |

Unofficial Transcript

COURSES IN PROGRESS **-Top-**

Spring Quarter 2008

| College: | | Graduate Studies | | |
|----------------------|---------------|--------------------------|--------------|----------------------------|
| Major: | | Ecology | | |
| Student Type: | | Continuing | | |
| Subject | Course | Title | Units | Start and End Dates |
| ECL | 290 | Seminar In Ecology | 1.000 | |
| ECL | 290 | Seminar In Ecology | 1.000 | |
| ECL | 296 | Topics In Ecol and Evol | 1.000 | |
| PLS | 206 | Applied Multivariate Mod | 4.000 | |
| WFC | 299 | Research | 7.000 | |

Record of Academic Work for Advisement Only

SANDSTROM PHILIP
Fri Jun 6 11:41:58 2008

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ONLINE RECORD OF ACADEMIC WORK

06/06/2008

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SCHOOL: SCIENCE & MATH

STUDENT NAME: SANDSTROM PHILIP

MAJOR: MARINE SCIENCE

STUDENT NBR: XXX XX 9337

DEGREE: BACHELOR OF SCIENCE

TERM APPLIED: 20034 FALL 2003

ADVISOR: STANCYK

SE

BASIS TYPE: TC BACHELOR PROGRAM

BEGINNING OF UNDERGRADUATE RECORD

DEGREE(S) AWARDED:

FALL 2004

DEGREE: BACHELOR OF SCIENCE

SCHOOL: COLLEGE OF SCIENCE AND MATHEMATICS

MAJOR: MARINE SCIENCE

HONORS: CUM LAUDE

UG HED: CREDIT COUNTED TOWARD THE USC DEGREE IS DETERMINED BY
STUDENT'S MAJOR PROGRAM OF STUDY.

| EQUIVALENT COURSE TITLE DEPT CRSE | DEPT | COURSE | GRADE OLD | HOURS NEW | EARNED | CREDIT TYPE |
|---|-------------------|--------|--------------|--------------|-----------|-------------|
| SPRING 2001 06/2002 | UNIV NORTHRN IOWA | | | | 01/2001 - | |
| ORAL COMMUNICATION SPCH 140 | 48C | 001 | B | 3.00 | TRANSFER | |
| NATIVE NORTH AMERICA HIST 100* | 680 | 132 | B | 3.00 | TRANSFER | |
| GENERAL BIO I BIOL 101 | 840 | 051 | C | 4.00 | TRANSFER | |
| GENERAL CHEMISTRY I CHEM 111 | 860 | 044 | C | 4.00 | TRANSFER | |
| SUMMER I 2001 06/2002 | UNIV NORTHRN IOWA | | | | 01/2001 - | |
| GENERAL BIO II BIOL 102 | 840 | 052 | B | 4.00 | TRANSFER | |
| FALL 2001 06/2002 | UNIV NORTHRN IOWA | | | | 01/2001 - | |
| COLLEGE RDNG & WRTNG NONE | 620 | 005 | W | 0.00 | TRANS-W/D | |
| ELEMENTARY ANALYSIS MATH 115 | 800 | 046 | B | 4.00 | TRANSFER | |
| GENERAL CHEMISTRY II CHEM 112 | 860 | 048 | C+ | 4.00 | TRANSFER | |
| PHYSICAL GEOLOGY GEOL 101 | 870 | 031 | A | 4.00 | TRANSFER | |
| INDEPENDENT STUDY ELEC 300* | 980 | 198 | A | 3.00 | TRANSFER | |
| SPRING 2002 06/2002 | UNIV NORTHRN IOWA | | | | 01/2001 - | |
| GENETICS BIOL 303 | 840 | 140G | A | 4.00 | TRANSFER | |
| SEM INSPIRING BIOLOGY ELEC 100* | 840 | 189 | A | 1.00 | TRANSFER | |
| ORGANIC CHEMISTRY I CHEM 333 | 860 | 120 | C+ | 3.00 | TRANSFER | |
| OCEANOGRAPHY MSCI 312 | 870 | 165G | A | 3.00 | TRANSFER | |
| INDEPENDENT STUDY ELEC 10X* | 980 | 198 | A | 1.00 | TRANSFER | |
| SUMMER I 2002 06/2002 | UNIV NORTHRN IOWA | | | | 01/2001 - | |
| ORGANIC CHEMISTRY II CHEM 334 | 860 | 123 | B | 3.00 | TRANSFER | |

TRANSFER TOTALS: HRC- 48.00 HRE- 48.00 GHRS- 48.00 GPTS- 148.50
GPA-3.094

SPRING 2000 HAWKEYE COMMUNITY COLLEGE 01/2000 -
12/2000

| | | | | | |
|-----------------------|----|-----|---|------|----------|
| WESTERN CIVILIZATN II | HM | 102 | A | 4.00 | TRANSFER |
| HIST 102 | | | | | |
| WILDLIFE ECOLOGY | NR | 106 | A | 4.00 | TRANSFER |
| ELEC 200* | | | | | |
| ENVIRONMENTAL ISSUES | NS | 123 | A | 3.00 | TRANSFER |
| BIOL 270 | | | | | |
| INTRO TO SOCIOLOGY | SO | 100 | B | 3.00 | TRANSFER |
| SOCY 101 | | | | | |

SUMMER I 2000 HAWKEYE COMMUNITY COLLEGE 01/2000 -
12/2000

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|----------------------|----|-----|---|------|----------|
| WESTERN CIVILIZATN I | HM | 101 | A | 4.00 | TRANSFER |
| HIST 101 | | | | | |

FALL 2000 HAWKEYE COMMUNITY COLLEGE 01/2000 -
12/2000

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|-----------------------|----|-----|---|------|-----------|
| COMPOSITION I | CM | 113 | A | 3.00 | TRANSFER |
| ENGL 101 | | | | | |
| THE MOVIES:INTRO FILM | FA | 108 | A | 3.00 | TRANSFER |
| FILM 200* | | | | | |
| THE PACIFIC CENTURY | HM | 192 | W | 0.00 | TRANS-W/D |
| NONE | | | | | |
| INTRO TO LITERATURE | LR | 100 | A | 3.00 | TRANSFER |
| ENGL 102 | | | | | |
| DIVERSITY IN AMERICA | SO | 216 | A | 3.00 | TRANSFER |
| SOCY 100* | | | | | |
| AMERICAN CIVILIZATION | SS | 100 | A | 3.00 | TRANSFER |
| HIST 10** | | | | | |

TRANSFER TOTALS: HRC- 33.00 HRE- 33.00 GHRS- 33.00 GPTS- 129.00
GPA-3.909

UGRAD TRANSFER MAJOR 146

SEMESTER TOTALS: HRC- 0.00 HRE- 0.00 GHRS- 0.00 GPTS- 0.00
GPA-0.000

CUMULATIVE TOTALS: HRC- 0.00 HRE- 81.00 GHRS- 0.00 GPTS- 0.00
GPA-0.000

FALL 2002 CONT ED H.S./DISTANCE MAJOR 100

| | | | | |
|--------------------------|------|------|----|------|
| ECOLOGY AND EVOLUTION | BIOL | 301 | B+ | 3.00 |
| ECOLOGY&EVOLUTION LAB | BIOL | 301L | A | 1.00 |
| EVOLUTN MARINE ENVIRONMT | MSCI | 111 | A | 4.00 |
| BIOLOGY-MARINE ORGANISMS | MSCI | 311 | A | 4.00 |
| MARINE ECOLOGY | MSCI | 575 | A | 3.00 |

SEMESTER TOTALS: HRC- 15.00 HRE- 15.00 GHRS- 15.00 GPTS- 58.50

GPA-3.900

CUMULATIVE TOTALS: HRC- 15.00 HRE- 96.00 GHRS- 15.00 GPTS- 58.50

GPA-3.900

DEAN'S HONOR LIST

| SPRING 2003 | CONT ED H.S./DISTANCE | MAJOR | 100 |
|--------------------------|-----------------------|-------|------|
| PROCESSES IN MARINE ENVI | MSCI 112 | A | 4.00 |
| MARINE PLANTS | MSCI 525 | A | 4.00 |
| ICHTHYOLOGY | MSCI 536 | A | 4.00 |

SEMESTER TOTALS: HRC- 12.00 HRE- 12.00 GHRS- 12.00 GPTS- 48.00

GPA-4.000

CUMULATIVE TOTALS: HRC- 27.00 HRE-108.00 GHRS- 27.00 GPTS- 106.50

GPA-3.944

PRESIDENT'S HONOR LIST

| FALL 2003 | SCIENCE & MATH | MAJOR | 146 |
|-------------------------|----------------|-------|------|
| PRIMATES PEOPLE PREHIST | ANTH E101 | A | 3.00 |
| BEGINNING GERMAN | GERM 109 | A | 3.00 |
| CALCULUS I | MATH 141 | B+ | 4.00 |
| COASTAL PROCESSES | MSCI 557 | W | 0.00 |
| GENERAL PHYSICS I | PHYS 201 | B+ | 3.00 |
| GENERAL PHYSICS I LAB | PHYS 201L | A | 1.00 |

SEMESTER TOTALS: HRC- 14.00 HRE- 14.00 GHRS- 14.00 GPTS- 52.50

GPA-3.750

CUMULATIVE TOTALS: HRC- 41.00 HRE-122.00 GHRS- 41.00 GPTS- 159.00

GPA-3.878

DEAN'S HONOR LIST

| SPRING 2004 | SCIENCE & MATH | MAJOR | 146 |
|------------------------|----------------|-------|------|
| BEGINNING GERMAN | GERM 110 | B+ | 3.00 |
| CALCULUS II | MATH 142 | B+ | 4.00 |
| OCEAN DATA ANALYSIS | MSCI 305 | A | 3.00 |
| PHYS&CHEM OCEANOGRAPHY | MSCI 312 | A | 4.00 |
| GENERAL PHYSICS II | PHYS 202 | B | 3.00 |
| GENERAL PHYSICS II LAB | PHYS 202L | A | 1.00 |

SEMESTER TOTALS: HRC- 18.00 HRE- 18.00 GHRS- 18.00 GPTS- 65.50

GPA-3.639

CUMULATIVE TOTALS: HRC- 59.00 HRE-140.00 GHRS- 59.00 GPTS- 224.50

GPA-3.805

DEAN'S HONOR LIST

| SUMMER I 2004 | SCIENCE & MATH | MAJOR | 146 |
|------------------------|----------------|-------|------|
| FIELD&LAB INVESTIGATNS | MSCI 460M | A | 4.00 |

SEMESTER TOTALS: HRC- 4.00 HRE- 4.00 GHRS- 4.00 GPTS- 16.00

GPA-4.000

CUMULATIVE TOTALS: HRC- 63.00 HRE-144.00 GHRS- 63.00 GPTS- 240.50

GPA-3.817

| FALL 2004 | SCIENCE & MATH | MAJOR | 146 |
|-----------|----------------|-------|-----|
|-----------|----------------|-------|-----|

| | | | | |
|------------------------|------|------|----|------|
| ANIMAL BEHAVIOR | BIOL | 534 | B+ | 3.00 |
| ANIMAL BEHAVIOR LAB | BIOL | 534L | A | 1.00 |
| BASIC PROFICIENCY/GERM | GERM | 122 | A | 3.00 |
| SENIOR SEMINAR | MSCI | 505 | A | 1.00 |
| AQUATIC CHEMISTRY | MSCI | 624 | A | 3.00 |
| STATISTICAL METHODS I | STAT | 515 | B+ | 3.00 |

SEMESTER TOTALS: HRC- 14.00 HRE- 14.00 GHRS- 14.00 GPTS- 53.00
GPA-3.786

CUMULATIVE TOTALS: HRC- 77.00 HRE-158.00 GHRS- 77.00 GPTS- 293.50
GPA-3.812

DEAN'S HONOR LIST

| UNDERGRADUATE TOTALS | | HC | HE | GH | GP |
|----------------------|--------------------|--------|--------|--------|--------|
| GPA | | | | | |
| | NON U.S.C. | 81.00 | 81.00 | 81.00 | 277.50 |
| 3.426 | | | | | |
| | USC SYSTEM | 77.00 | 77.00 | 77.00 | 293.50 |
| 3.812 | | | | | |
| | COLLEGIATE SUMMARY | 158.00 | 158.00 | 158.00 | 571.00 |
| 3.614 | | | | | |

*** END OF UNDERGRADUATE RECORD ***

*** END OF ACADEMIC RECORD ***



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
Fisheries Ecology Division
110 Shaffer Road
Santa Cruz, CA 95060

June 5, 2008

Dear Sir or Madam:

I would like to recommend Philip Sandstrom, a graduate student in Ecology at the University of California Davis, for a CALFED Fellowship. Phil has worked on our CALFED-funded juvenile salmonid tracking project for the last two years. He has been an integral part of the success of the study conducting range tests, assisting with tagging studies, field work, giving presentations at scientific conferences, and helping to guide the project. He has served as a leader for the UC Davis research team and worked as a fisheries specialist deploying acoustic monitors throughout the Sacramento River and Delta, tagging fish, and manually tracking steelhead. Phil is very responsible and has also done a good job handling several administrative tasks and permitting issues. He wrote the animal care protocol for UC Davis and handled encroachment permits for work in the bay. Throughout his time as a fisheries specialist and graduate student he has collaborated well with our group at NMFS and other members of the California Fish Tracking Consortium. He is a highly motivated, ceaseless worker who is constantly working long hours in the field and improving our current project design.

In the past two years Phil has started a side project of his own accord manually tracking juvenile steelhead. I know that he has put a great deal of effort into this project and shown strong leadership skills while still maintaining his responsibilities to the larger study. He has tracked four fish thus far, and taken environmental data via a Hydrolab throughout the continuous five-day fish tracking. He has prepared the data and given informative and entertaining talks at several conferences, such as the 137th annual American Fisheries Society Meeting and the International Advances in Tagging and Marking Technology in New Zealand. His work has illustrated the behavioral responses and movement patterns of juveniles to tidal flows in the Delta. Phil is constantly learning, developing new hypotheses, and has done a good job identifying trends and patterns in the data.

We selected Phil for this project because of his strong academic background at the University of South Carolina and his extensive field and laboratory experience in fisheries science. I recall that he had a rigorous course curriculum at the University of South Carolina and was in the top of his class with a GPA above 3.8. He requested and we sent him to a workshop on mark-recapture to learn to use Program MARK, a modeling program, for our study. Since being admitted to the UC Davis he has taken courses pertinent to our project such as theoretical ecology, mathematical population biology, and a seminar on synchrony from Professor Alan Hastings, a premier scholar in population dynamics and modeling. He has also studied multivariate statistics and core principles in ecology. Phil has performed well in his classes since becoming a member of the graduate group in ecology.

I have reviewed Phil's proposal and am convinced he will accomplish the goals outlined in the study. Phil has been one of the best student/worker I have had the pleasure to work with. He has been a great asset to our smolt project and would expect the same in any task that he takes on. I agree that the addition of wild and hatchery kelts will benefit several of the current on-going projects in the California Fish Tracking Consortium. There is relatively little known about adult wild steelhead trout and a telemetry study would go a long way in developing a better understanding of their behavior in relation to water dynamics in the Delta. With his experience and the guidance of the faculty at UC Davis and members of the California Fish Tracking Consortium I am sure that this project will be a success. Phil is very deserving of this fellowship, and will produce results critical to Central Valley salmonid management.

Sincerely,

R. Bruce MacFarlane, Ph.D.
Leader, Salmon Ecology





DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION
FAX: (530) 752-4154

ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8751

6 May 2008

Ms. Shauna Oh
California Sea Grant
9500 Gilman Dr., #0232
La Jolla, CA 92093-023

Dear Ms Oh:

This is a letter supporting Philip Sandstrom's application for a CALFED Fellowship. I have known Phil for three and a half years in the capacity of both as an employer and a teacher. After graduating from the University of South Carolina, he enquired about seeking an advanced degree in the Ecology Graduate Group working in my laboratory. He worked for me for one and a half years as a Fisheries Specialist, and served as a leader of a large research team, consisting of UC Davis and NMFS biologists, conducting a watershed-wide study funded by CALFED, aimed at determining reach-specific rates of movement and survival of late-fall run Chinook and steelhead. He and his colleagues placed coded-ultrasonic beacons on 200 smolts of each species during January 2007, and immediately prior deployed roughly 60 tag-detecting monitors along the length of the Sacramento River, within the Delta, and in Suisun Bay. Furthermore, he also participated in range tests to determine the distance of tag reception in the river, bay, and reservoir, and analyzed results from these tests.

On his own initiative, he has tracked four steelhead smolts for periods ranging from two to five days, while recording a continuous record of their depths. Two smolts were tracked in the mainstem of the Sacramento River and two within Suisun Bay. Not only were the geographical coordinates of the fish recorded with the telemetered depths, but water was pumped into a shipboard tank, and a Hydrolab measured water conductivity, salinity, pH, temperature, and concentration of dissolved oxygen and paired these measurements with depths recorded by a fathometer. At hourly intervals he dropped the Hydrolab to measure these physical properties at increasing depths. He found that steelhead change their swimming direction in response to changes in the direction of the tidal flow within the bay. He recently gave a talk on his steelhead smolt study at the San Francisco meeting of the American Fisheries Society and displayed a poster on this work at the biennial State of the Estuary meeting in Oakland. This is the first tracking of steelhead smolts, of which I am aware, and is of great interest to regional fisheries biologists and resource managers. He has also determined that the steelhead released in the Sacramento River, stay in place until winter rains increase the flows, and it is at this time that they begin to migrate down the river. A question of great interest to anadromous fish biologists on the western coast of North America now is what makes a rainbow trout become a steelhead, and make an oceanic migration, rather than staying landlocked.

Phil began his graduate studies this fall in the Ecology Graduate Group at the University of California, which is rated the top program of its kind in the nation. He had a GPA of 3.85 while at the University of South Carolina, and was a top scholar there. He has fit in admirably here at UC Davis, and is a leader among his class mates, having already conducted tracking studies on steelhead and will have access to the files of tag-detections of both juvenile and adult steelhead from close to 200 automated

monitors distributed throughout the watershed for his thesis work. I am confident that he will perform world-class, dissertation research. This fellowship will add to the support already in hand (i.e., tags and monitors), and thus is an efficient use of valuable CALFED funding.

I have great expectations for Phil as a graduate student, most wholeheartedly recommend him for this fellowship, and will provide ample guidance to him to ensure that his research is of the highest quality.

Cheers,

A. Peter Klimley, Ph.D.
Adjunct Professor
Director, Biotelemetry Laboratory

California Bay-Delta Authority
Science Fellows Program
California Sea Grant College Program University of California, San Diego
9500 Gilman Drive Dept. 0232 La Jolla, CA 92093-0232

Subject: Pre-doctoral Application; Community mentor

June 5, 2008

To Whom It May Concern,

I am writing in support of Phil Sandstrom's application to the pre-doctoral CALFED Science Fellows Program in cooperation with the California Sea Grant College Program. Furthermore, I would like to offer myself as a community mentor for his proposed study of Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks.

Phil is a bright and motivated person. He has taken on the coordination of a major California Central Valley monitoring project lead by Dr. Pete Klimley's lab at the University of California. He has shown excellent interpersonal skills, the ability to coordinate with numerous groups of various backgrounds and has put in tireless hours of field monitoring and data management for this project.

Furthermore, Phil has shown initiative in creating collaboration within the scientific community by chairing both a poster and oral session related to acoustic radio telemetry studies of salmonids within the Central Valley for the CALFED Science Conference.

Phil is a pleasure to work with and I consistently hear positive comments from other scientists within this community about Phil Sandstrom.

In conclusion, I wholeheartedly support Phil Sandstrom in this endeavor and look forward to our continued collaboration.

Sincerely,

A handwritten signature in black ink, appearing to read 'Joe E. Merz', with a stylized, looping flourish at the end.

Joseph E. Merz, Ph.D.
Research Fellow, Institute of Marine Sciences
University of California Santa Cruz and
Principal Restoration Ecologist
Cramer Fish Sciences

California Bay-Delta Authority
Science Fellows Program
California Sea Grant College Program University of California, San Diego
9500 Gilman Drive Dept. 0232 La Jolla, CA 92093-0232

Subject: Pre-doctoral Application; Community mentor

June 5, 2008

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I am writing in support of Phil Sandstrom's application to the pre-doctoral CALFED Science Fellows Program in cooperation with the California Sea Grant College Program. Furthermore, I would like to offer myself as a community mentor for his proposed study of Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks.

The Sacramento San Joaquin System supports Chinook salmon and steelhead runs, important resources vital to California's economy and ecology. I have been monitoring salmonid resources of the California Central Valley for the past 18 years. This work has included monitoring migration, spawning and riverine habitat use. Furthermore, I perform habitat enhancement projects, including spawning and rearing habitat rehabilitation and I have taken part in several projects supported by CALFED, including the mentoring of other students.

The monitoring, maintenance and enhancement of river salmonid resources is vital to their long term management and the overall ecology of the Central Valley system. In 2006, I began a partnership with the University of California, Davis, University of California, Santa Cruz and East Bay Municipal Utility District to track hatchery and wild steelhead habitat use and migration patterns in the Mokelumne River, California. Furthermore, my colleagues, students and I are modeling Chinook salmon migration decisions through the Sacramento San Joaquin System. Phil's project is an important expansion on these efforts, developing a new aspect of collaboration between my work and UC Davis and expanding our overall understanding of steelhead to address unanswered questions. Phil's project also extends steelhead work into the Sacramento River system, which adds great complexity and dynamics to what we have learned so far.

I have an excellent working relationship with Dr. A. Pete Klimley, Phil's university advisor, which will strengthen his support network. I will be able to work with Phil during his field surveys and provide collaboration with other scientists and students in the area. We operate rotary screw traps, and perform fish community surveys several times throughout the year which will expand opportunities for Phil to access fish. My staff and I have years of experience operating on various river systems and we have vehicles and boats at our disposal to compliment Phil's already impressive UC Davis support group. Phil, Pete and I plan to collaborate closely on our research into answering key questions about steelhead life history and management in the Central Valley. We plan to co-author papers, grants, and reports addressing the wide variety of science-management questions which expand our understanding of steelhead. Phil's project will be an important contribution to CALFED science, providing data and analysis to improve our ability to provide new, supported management strategies for key species, particularly steelhead.

In conclusion, I wholeheartedly support Phil Sandstrom in this endeavor and look forward to our continued collaboration.

Sincerely,



Joseph E. Merz, Ph.D.
Research Fellow, Institute of Marine Sciences
University of California Santa Cruz and
Principal Restoration Ecologist
Cramer Fish Sciences

California Bay Delta Authority
Science Fellows Program
California Sea Grant College Program – University of California San Diego
9500 Gilman Drive Dept. 0232 La Jolla, Ca. 92093

Subject: Pre-doctoral Application letter of support for Phil Sandstrom

June 6, 2008

To Whom It May Concern:

I am writing this letter in support of Phil Sandstrom's application for the pre-doctoral CALFED Science Fellows Program and his proposed study "Sacramento River steelhead trout: An assessment of behavioral differences and contributions of hatchery and wild stocks".

I am a fisheries biologist working on Central Valley salmonid issues. For the past 15 years I have lead monitoring programs related to migration of both adult and juvenile salmonids in the Central Valley. I have had the opportunity to collaborate with Phil over the past two years on the Central Valley Fish Tracking Consortium. In this capacity Phil has been a leader in communication between many agencies and stakeholders in the Bay Delta system and has been instrumental in ensuring true collaboration between all parties.

Phil's proposed study will expand help expand our knowledge of Central Valley Steelhead and answer some long asked questions related to hatchery and wild population similarities and differences. Phil has shown himself to be a hard working, dedicated and intelligent individual and his research will be an important contribution to CALFED science key species management.

Sincerely,

Michelle L. Workman
Supervising Fisheries and Wildlife Biologist
East Bay Municipal Utility District

1 Winemaster Way Ste K, Lodi, Ca. 95240 (209)365-1486



6 June 2008

California Bay-Delta Authority
Science Fellows Program
California Sea Grant College Program
University of California, San Diego
9500 Gilman Drive Department 0232
La Jolla, California 92093-0232

Subject: Community Support for Phil Sandstrom's Application

To Whom It May Concern,

I am writing in support of Phil Sandstrom's application to the CALFED Science Fellows Program in cooperation with the California Sea Grant College Program. In particular, I support his proposed research to examine behavioral differences of hatchery vs. wild stocks of Sacramento River steelhead.

I am currently the Study Manager for the LTMS (Long Term Management Strategy) and US Army Corps of Engineers-sponsored salmonid tracking study in San Francisco Bay. We have many study partners in this endeavor, including UC Davis Biotelemetry lab (Pete Klimley's group), UC Santa Cruz and NOAA/NMFS lab at Santa Cruz (Bruce MacFarlane's group), USFWS (Pat Brandes' group), CDFG, Ports of San Francisco, Oakland, and Stockton, East Bay Municipal Utility, and many others. Through this collaborative multi-agency effort (including CalFed funding for the UC Davis and NOAA/NMFS Santa Cruz lab effort), Chinook salmon and steelhead smolts implanted with ultrasonic tags are being released. As the smolts move from the Sacramento River, through the Estuary, and under the Golden Gate Bridge during their outmigration, they are detected by strategically-located hydrophones placed to better define juvenile salmonid migratory routes, transit times, and distribution relative to dredging and dredged material placement sites, thus providing the information needed to make management decisions.

Phil's project will benefit our salmonid tracking study program by adding an additional life stage (steelhead adult) to our study effort, since we are currently only tagging smolt Chinook salmon and steelhead. In addition, the data from Phil's research will go a long way towards development of a model for steelhead populations in the central valley.

This project is one part of a multi-agency/research institute project which has the common goal to gain knowledge about the migratory behavior of native anadromous species in the Sacramento-San Joaquin River Delta and Estuary, for the protection of these species habitats.

Sincerely,

Thomas P. Keegan
Director, Aquatic Resources Group
ECORP Consulting, Inc.
2525 Warren Drive
Rocklin, California 95677
Phone: (916) 782.9100

HAEMailroom/TPK/SandstormSupportLetter